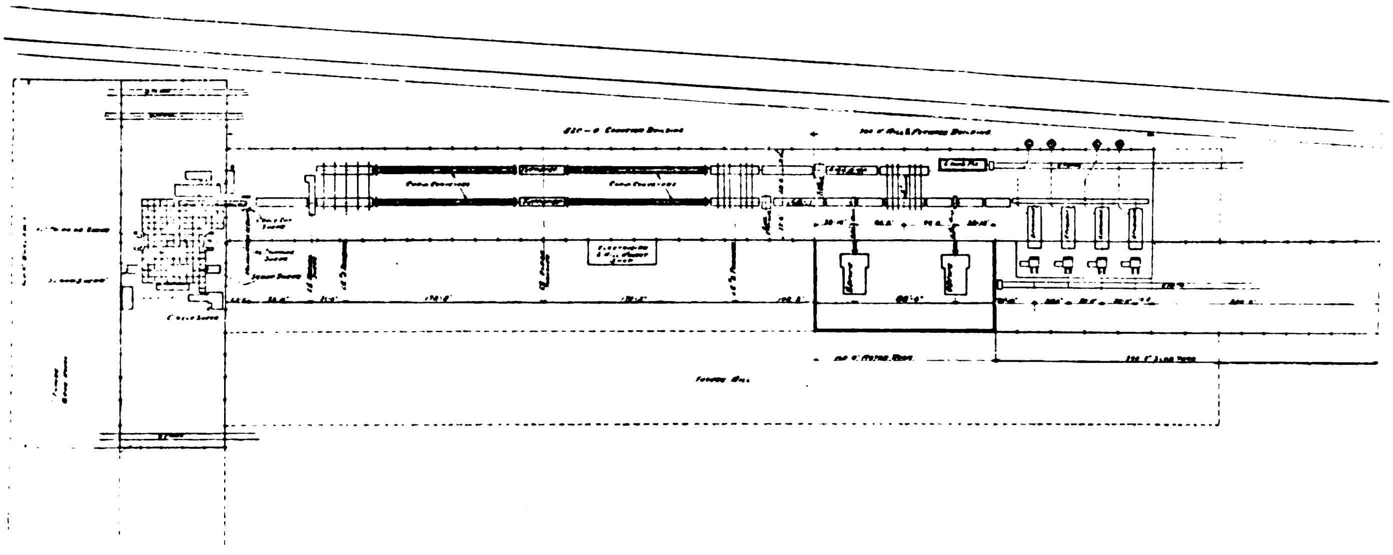
The Blast Furnace and Steel Plant

Youngstown Sheet and Tube Plate Mill

Tandem Plate Mill Designed to Roll 15,000 Tons of Plates Per Month — Absence of Hydraulic and Steam Machinery and Grouping of Controlling Apparatus Are Distinctive Features.

The following is a general description of the tandem plate mill erected by the Youngstown Sheet & Tube Company, at the East Youngstown plant, and which was put in operation on June 17 of this year. The mill is originally designed to finish a sheared plate 74 inches wide, in lengths up to 50 feet. This mill is designed to roll plates from slabs which are furnished in required sizes by the blooming mills, and will produce an average of 15,000 tons of plates per month. The distinctive features of the mill are the absence of hydraulic and steam machinery, the elimination of all exposed wiring, the grouping of controlling apparatus at a minimum number of points and the double line of cooling tables.



General plan of buildings covering approximately 210,000 square feet—The diagram shows the mill and furnace building, slab yard, motor room, conveyor building and warehouse.

Buildings.

The total floor space occupied by the plate mill buildings are approximately 210,000 square feet. The buildings are as follows:

Mill and furnace building 80 feet wide by 300 feet long (shown at the right of Fig. 1), which houses both mills and the continuous heating furnaces, and is equipped with a 40-ton crane with 15-ton auxiliary hoist and standard gage track for unloading materials.

The slab yard is 80 feet wide and 340 feet long and is equipped with two 10-ton single hook cranes with magnet drum and standard and narrow gage tracks for handling slabs. This building is built parallel with the mill buildings.

The motor room is 80 feet wide by 160 feet long, with brick walls, and is built parallel with the mill buildings. It houses the two 2,000-hp motors which drive the mills and all control equipment for them, and is equipped with a 20-ton single hook crane and standard gage track.

The conveyor building is 80 feet wide by 520 feet long, and is in line with the mill and furnace building. It houses the conveying machinery, straighteners, turnovers, rotary shear and end-cut shear, and is equipped with a 10-ton single hook crane.

The warehouse is 93 feet wide by 320 feet long and is placed at the end of, and at right angles to, the conveyor building. It houses the trimming shears, circle shear, castor floor and shipping tracks, and is equipped with two 10-ton cranes with magnet drum.

The buildings are of steel construction and were furnished and erected by the Blaw-Knox Company, of Pittsburgh, Pa., much study being spent on the lighting and ventilation.

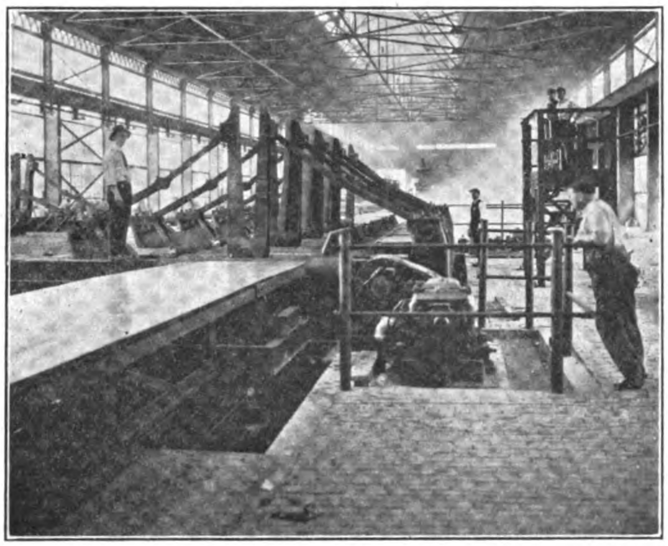


Plate turnover with which any width of plate may be turned over and retain its relative position on the tables, thereby eliminating the pullovers usually necessary.

All of the buildings except the slab yard are built with the Pond type inverted monitor roof and equipped with Lupton top-hung sash and operates in the monitor, and with United Steel sash, furnished by the Trussed Concrete Steel Company for the side walls. The side wall sash consists of two runs of continuous sliding sash, each 5 feet high around all buildings, except the motor room, which building, having brick wall, is provided with ample pivoted ventilating sash.

The 40-ton crane in the mill building, and the 20-ton crane in the motor room, are of massive construction and were furnished by the Cleveland Crane & Engineering Company. The 10-ton cranes in the rest of the buildings are extremely high speed and are well adapted to the service which they perform. These cranes were furnished by the V. R. Browning Company.

Furnaces.

There are four Laughlin gravity discharge continuous heating furnaces, 12 feet wide by 45 feet long over all, and are operated on coke oven gas. Each furnace is equipped with an electrically driven slab pusher, built by the United Engineering & Foundry Company. A motor-driven slab table, built by the Morgan Engineering Company, delivers the slabs to the mill tables. The floor around the furnaces is raised to a convenient height for operation by means of retaining walls of concrete, and the permanent fill, which is paved with brick. This feature eliminates the use of all steel or wooden platforms such as are usually used for this purpose.

Roll Stands.

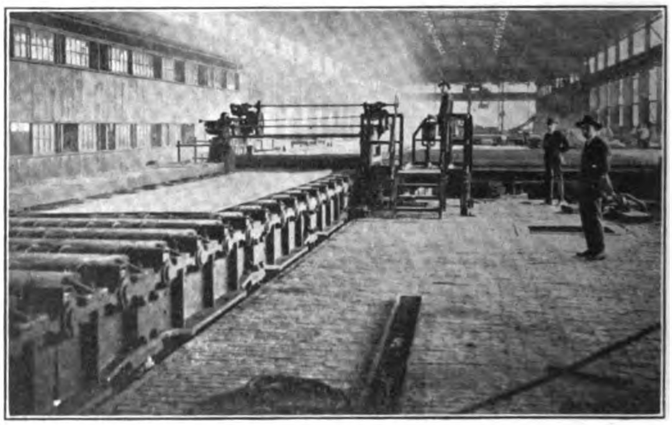
The roughing and finishing are duplicates in all respects, except for a difference of 12 inches in the length of the rolls. They are of the three-high type with 32-inch top and bottom rolls and 22-inch middle rolls, and were furnished complete with tilting tables and pinions by the Mesta Machine Company. The middle roll-lifting mechanism as well as the table-tilting mechanism are electrically operated, in fact, the only hydraulic power used on the entire layout is a constant pressure cylinder for balancing the top roll.

Each mill is driven by a 2,000-hp, 6,600-volt, 25-cycle, 3-phase induction motor, which runs at 81 r. p. m. and is connected by spindles to the middle pinion in the pinion housing. The speed reduction in the pinion housing is as 14 to 20; therefore, the speed of the mill rolls is 56 r. p. m. These motors were furnished by the Allis-Chalmers Manufacturing Company. The mills are of massive construction and of the very latest design in plate mill practice.

The roll stands are located tandem, 88 feet 4 inches apart, and the intervening space is occupied by an intermediate table which also acts as a receiving end for a chain transfer for moving the plates for the second line of tables which, run parallel to the mill tables and at a distance of 28 feet 6 inches apart. These tables were also built by Mesta Machine Company.

Runout Tables, Conveyors and Straighteners.

The plates are straightened by Hilles & Jones plate straightening machines of which there are two, one on each line of tables. The straightener tables were furnished by Treadwell Engineering Company and are equipped with collared rollers which permits of an air space under the plates to prevent unequal cooling.



Straightening rolls.

The chain conveyors were built by Heyl & Patterson Company, and are located in front of and beyond the plate turnovers. The conveyors in front of the turnovers being used as cooling tables and those beyond as marking tables. These conveyors are of the roller-chain type, of four strands each. The two transfers in the conveyor building are of the chain pullover type, each pullover being equipped with two dogs, and were furnished by the Treadwell Engineering Company. The first transfer is located 105 feet 5 inches from the center of the 84-inch mill, and the second one 448 feet 5 inches from the same point.

Plate Turnovers.

The two plate turnovers are unique in many respects, being designed to eliminate the inherent defects in the ordinary type. These machines are of a type patented by William Forsstrom, chief engineer of the Youngstown Sheet & Tube Company, and were built by the Treadwell Engineering Company. With these machines any width of plate may be turned over and will retain its relative position on the tables, thereby eliminating the pullovers which are necessary with the ordinary type. A plate may also be lifted to a position convenient for examining the under side and then returned to the table without being turned over. They are much faster than the ordinary type, due to the fact that they make one complete turning operation with the forward stroke and one also with the return.

The plate is turned by a series of forks or cradles which are located between the rollers of the turnover tables. The bottom of the fork is carried in a moving pivot which travels in a parallel line across the table, the upper end of the forks are connected by flexible links to stationary posts on either side of the table, one to each side. The turning action is accomplished by moving the pivot which carries the bottom of the fork in a direct line across the table, the travel of the upper ends of the forks being restricted by the links, the fork will turn itself over in its own length, thereby turning the plate which is held therein. This mechanism is moved by rack beams actuated by pinions mounted on a common driving shaft which is in turn driven by a 40-hp electric motor.

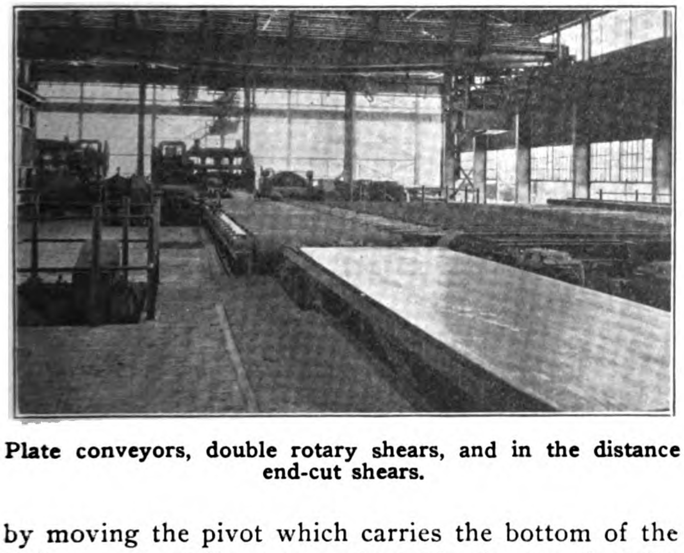
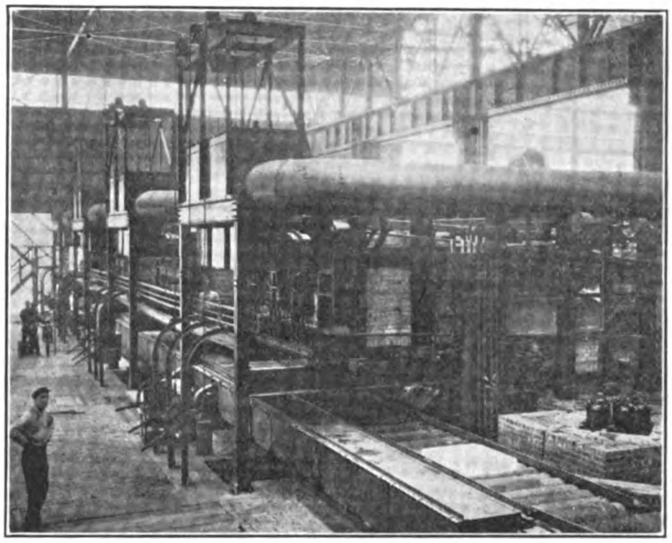


Plate conveyors, double rotary shears, and in the distance end-cut shears.



Laughlin gravity discharge continuous heating furnaces, 12 feet wide by 45 feet long, operated on coke oven gas.

Shear and Shipping Department.

Ample facilities have been provided for handling the finished product in the shear and shipping end.

All parallel plates up to and including 1-inch thickness will be side trimmed on a Newbold double rotary trimming shear which is located 480 feet from the 84-inch mill and 60 feet in front of the end-cut shear. The table in front of the end-cut shear is provided with a straight edge to facilitate the squaring of all plates which have been side trimmed. The end-cut shear is a Hilles & Jones Company No. 6½ gate shear, 112 inches between housings.

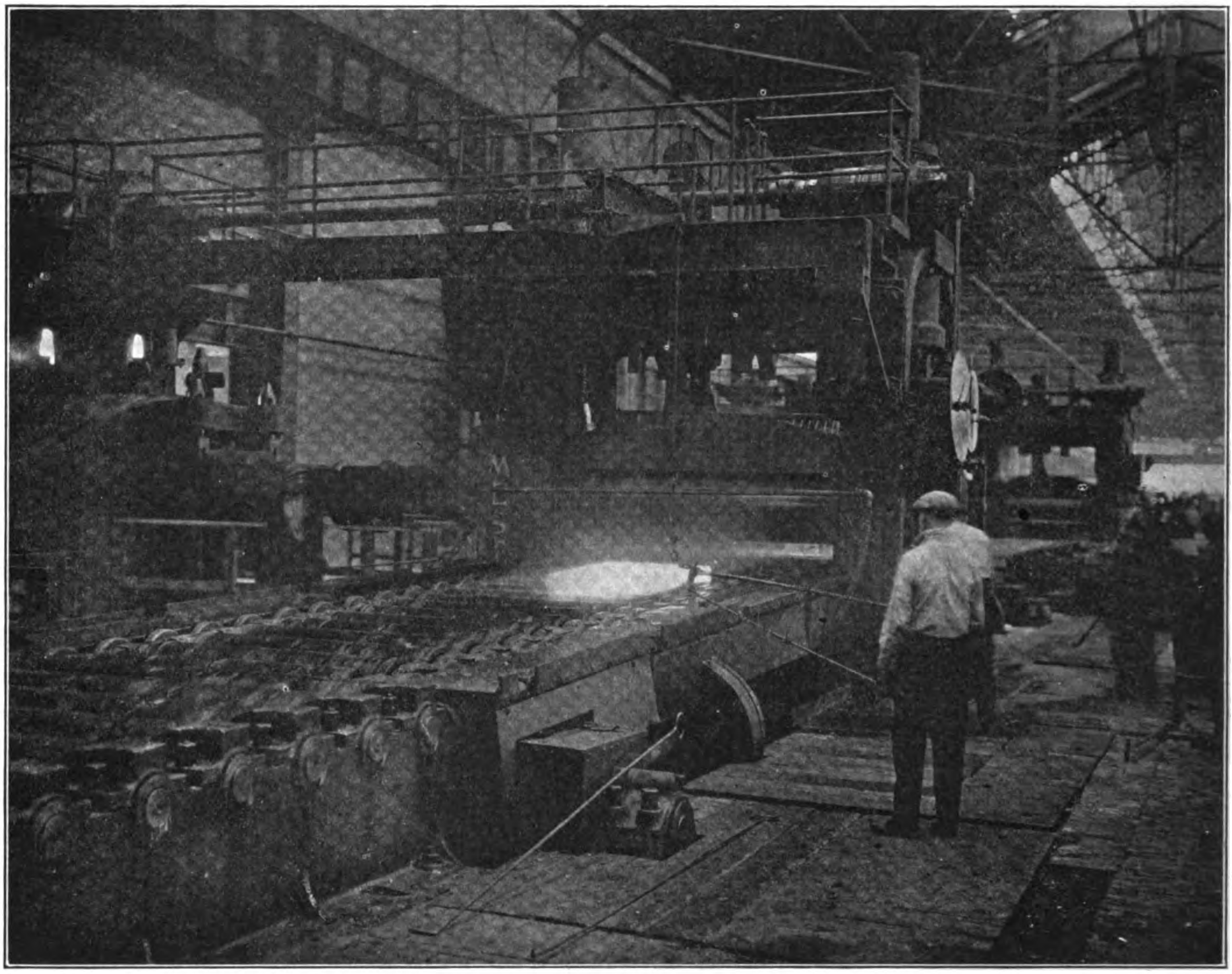
It is provided with a back shear table which was built by the Mesta Machine Company and which is a combined shear runout and scale table. A 40-foot double beam Fairbanks scale is located under this table, with lifting arms which can be raised at will to lift the plates from the table and weigh them. The plates may then be discharged by these same arms onto a plate rack, which is located beside the table, or it may be pulled off onto the castor floor.

All sketch plates and plates over ¾-inch thickness will be trimmed on two 146-inch Hilles & Jones gate shears which are located, one on either side of the castor floor. A Newbold circle-cutting machine is provided to cut circle and radius plates.

The warehouse is equipped with ample castor floor and two additional plate scales. It is also provided with three depressed shipping tracks, and all plates are handled by high speed 10-ton cranes provided with equalizer bars on which magnets or hooks may be used.

Electric Power.

The electric power for operating the mill is furnished by the main power plants and delivered by high tension underground system to a sub-station near the plate mill. This sub-station is equipped with three 6,600 to 240-volt General Electric motor generator sets, for providing the power for the DC General Electric type MD motors which drive the mill machinery. The 2,000-hp main mill motors are driven directly from the 6,600-volt system. All control apparatus for these large motors is contained in the motor room. This control apparatus was furnished by the Cutler-Hammer Manufacturing Company and the entire electric system in the motor room is of bus-bar construction. The power for the direct-current motors used on the mill machinery is delivered from the sub-tation to four centralized stations in which all of the control apparatus for the entire mill is grouped. These four main leads comprise all of the exposed power wiring in the plant, as all of the wiring from the control houses to the machinery and to the pulpit is carried in underground conduit imbedded in the concrete. This system eliminates all unsightly wiring and is vastly superior to any other from a safety viewpoint. Control apparatus was designed and furnished by the Electric Controller & Manufacturing Company.



Showing the two roll stands which are duplicates with the exception of a difference of 12 inches in the length of rolls—The only hydraulic power used is a constant pressure cylinder for balancing the top roll—The entering side of the roughing mill is shown in the foreground.

A well-equipped mill office and millwrights' and electricians' shops have been built adjacent to the mill buildings, and all sanitary equipment, wash rooms and locker rooms are of ample size, well equipped and conveniently located. All engineering work on this installation was done by the engineering department of the Youngstown Sheet & Tube Company.

Substituting Powdered Coal for other Fuels

General Operation of Powdered Coal Plant—Comparisons of Operating and First Cost of Producer Gas, Natural Gas, Fuel Oil, Hand Fired Coal and Powdered Coal.

By C. F. HERINGTON.

The writer's attention was called to an article published in the April issue of THE BLAST FURNACE AND STEEL PLANT, in which comparisons were made between the three well-known fuels; natural gas, fuel oil, and powdered coal, and he wishes to take exception to the results shown in that article, as to costs of plants and operation.

Powdered coal is a fuel that is not new by any means, as it was used in England at least 45 years ago for cement burning, and at the present day 90 per cent of the cement made in this country is made by using powdered coal as fuel in the kilns. Powdered coal is the staple fuel of the metal-working industries, because of its wide distribution and fairly staple price. It may be secured from several sources by almost every consumer, and the coal industry is so widely controlled as to lead, generally, to favorable prices. Powdered coal competes with raw coal, fuel oil, natural gas and producer gas. The elementary factor in such competition is the B. t. u. cost. If a gallon of oil containing 140,000 B. t. u. costs 5 cents, then the B. t. u. derived when 1 cent is spent for fuel oil will be 28,000. If powdered coal containing 14,000 B. t. u. per pound can be purchased for ½ cent per pound or $10 a ton, then there are 28,000 B. t. u. obtained for each cent expended to buy coal. The two fuels are then on a parity, so far as B. t. u. cost goes, but any final analysis must consider also the comparative efficiencies in the furnace of the two fuels. If a cent's worth of coal will go farther, that is, last longer, or produce more in a given furnace, than a cent's worth of oil (even though both are represented by the same number of B. t. u.), then the powdered coal is to be preferred.

At the present time in the Pittsburgh district the average price of fuel oil is 10 cents per gallon and tends to become more expensive as the demand increases. Natural gas is 36 cents per 1,000 cubic feet; whereas, coal can be purchased and delivered at the works in prices ranging from $3 to $5 per ton.

But raw coal cannot be compared with powdered coal with respect to efficiency of combustion. With proper appliances and methods, the last produces an almost smokeless fire, with a steady, intense heat and maximum furnace temperatures.

The change from other fuels to powdered coal does not involve expensive furnace reconstruction except in some cases. Any furnace adapted for fuel oil and gas may, with slight changes, be utilized for powdered coal.

The coal to be used for pulverizing should be bituminous or semi-bituminous, either the slack or the run-of-mine. Coals rich in volatile matter are to be preferred. An advantage of slack over run-of-mine is, that it requires no preliminary crushing. The following analysis represents a dried coal that has been found to give good results:

Fixed carbon	54.00%
Volatile matter	32.75%
Ash	12.00%
Moisture	1.25%

General Operation of Powdered Coal Plant.

If not already in fine particles, the coal as received is crushed so as to pass through a ¾-inch ring. It is then dried in a direct heat contact drier. It usually requires from 30 to 50 pounds of coal burned on the grate to dry a ton of coal, and the percentage of moisture is reduced to about 1 per cent. This expenditure of heat in the drier is not a net loss, since no fuel of any kind ever burns in a furnace until the moisture contained therein has been evaporated.

Following the drying, the coal is pulverized in some one of the various types of pulverizer. It is ground so fine that 85 to 87 per cent will pass through a 200-mesh screen, and 95 to 98 per cent through a 100-mesh screen. An air-separating device is usually integral with the pulverizer. This carries off the finer particles of coal dust, while returning the grosser for regrinding.

The finely ground coal is now carried either to bins by screw conveyors or high pressure air, or conveyed by mixing one pound of coal dust with 60 to 70 cubic feet of air at low pressure through spiral riveted asphalt-coated pipe to the several furnaces as required. The furnace construction and operation must be such that the lining remains continuously hot, which implies a steady, uniform feeding of the coal. This feeding must be under positive control, along which must go a positive control of the air supply.

Comparisons of Operating Costs of Producer Gas, Natural Gas, Fuel Oil, Hand-fired Coal and Powdered Coal.

The following comparisons are not estimated facts, but are based on data secured from the operators themselves in each instance:

Producer Gas.

Take a plant having 20 hot mills, each mill having a capacity of 15 tons of steel rolled per day of 24 hours.

It requires 600 pounds coal burned in a gas producer to heat one ton of steel.

$$\frac{20 \times 15 \times 600}{2{,}000} = 90 \text{ tons of coal required.}$$

Coal—90 tons at $5	$450.00

Steam.

It requires one pound of steam to satisfactorily gasify one pound of coal in the average producer, therefore, 180,000 pounds of coal requires:

$$\frac{180{,}000}{30} = 6{,}000 \text{ boiler hp at .003 cents} \quad \$18.00$$

Labor.

One producer to three mills, or, we will say eight producers, one as a spare.

It requires one man per turn of eight hours to each producer at 30 cents per hour.

7 × 3 × (8 × 30)	$ 50.40
Repairs and supplies	3.00
Unloading coal—90 tons at 10 cents	9.00
Cleaning producers—one per day—extra labor	4.00
Unloading ashes—9 tons at 20 cents, including freight	1.80
Total cost per day for producer gas	$536.20

Natural Gas.

Same kind of furnaces, having the same tonnage per day.

It requires 4,000 cubic feet natural gas per ton of steel heated.

Gas—$4{,}000 \times 15 \times 20 = 1{,}200{,}000$ cubic feet gas.

1,200,000 cubic feet at 36 cents per M	$432.00
Labor—one man	4.00
Repairs and supplies	2.00
Total operating cost per day	$438.00

Fuel Oil.

Same kind of furnaces, having the same tonnage.

It requires 30 gallons of oil per ton of steel heated.

Oil—30 × 15 × 20 = 9,000 gallons at 10 cents	$900.00
Labor—one man	4.00
Repairs and supplies	3.00
Total operating cost per day	$907.00

Hand Fired Coal.

It requires 600 pounds of coal per ton of steel heated.

$$\text{Coal } \frac{600 \times 15 \times 20}{2{,}000} = 90 \text{ tons at \$5} \quad \$450.00$$

Labor—one man per mill per turn, handling coal and ashes at 30 cents	......
15 men × 8 hours × 30 cents × 3 turns	108.00
Repairs and supplies, shovels, wheelbarrows	6.00
Total operating cost per day	$564.00

Powdered Coal.

It requires 300 pounds of coal per ton of steel heated.

$$\text{Coal } \frac{300 \times 15 \times 20}{200} = 45 \text{ tons at \$5} \quad \$225.00$$

Labor—1 operator per turn at $4	12.00
2 assistants per turn at $3.50	21.00
Power—45 tons × 30 kw × .01 cent	13.50
Repairs and supplies	4.50
Total operating cost per day	$276.00

Summary.

Total operating daily costs:

Producer gas	$536.00
Natural gas	438.00
Fuel oil	907.00
Hand-fired coal	564.00
Powdered coal	276.00

The above results speak for themselves, and as mentioned before, they are not estimated figures, but are results based on actual operations.

Now, as to the first cost of each of these kinds of fuel plants—again let me give you some real figures—allowing, however, for some changes in prices during the past two years.

Producer Gas.

8 Producers at $4,000	$32,000.00
Building, foundations, excavating, erection	20,000.00
Coal trestle	6,000.00
Coal conveyors	8,000.00
Steam and water piping	5,000.00
Flues to furnaces	10,000.00
Stacks	4,500.00
Valves	2,500.00
Total first cost	$88,000.00

Natural Gas.

Piping	$ 8,500.00
Valves	1,500.00
Burners	2,000.00
Total first cost	$12,000.00

Fuel Oil.

6—10,000 gallon oil tanks at $1,500	$ 9,000.00
Unloading, excavation and erection	1,000.00
2 auxiliary pressure tanks in place	2,500.00
1 circulating pump and motor	500.00
Piping, fittings and valves	6,500.00
Steam and air connections to tanks	2,000.00
Connections to furnaces—40 × $100	4,000.00
Standpipes for tank cars	500.00
Pump and pump house	1,500.00
Blowers and secondary air	5,000.00
Total first cost	$32,500.00

Hand-fired Coal.

Cast iron grates, doors, etc	$ 3,000.00
Wheelbarrows, shovels, etc	1,000.00
Large stacks in furnace, dampers, etc	16,000.00
Total first cost	$20,000.00

Powdered Coal.

Capacity 60 tons in 24 hours.

Track hopper, reciprocating feeder, coal crusher, belt conveyor, magnetic separator, elevating machinery, gear reducers, storage bin, belt conveyor, automatic scale, dryer, dried coal bins, two pulverizers, two exhausters, collectors, piping, powdered coal storage bin, feed screws, automatic regulator, distributing blower, piping, stop cocks, controlling devices, burners, branch pipes, all for	$50,000.00
Building (30 × 60 × 40 feet)	8,000.00
Foundations	2,000.00
Motors, 200 hp at $20 per hp	4,000.00
Secondary air piping and blowers	4,000.00
Erection	6,000.00
Changes in furnaces—40 × $100	4,000.00
Total first cost	$78,000.00

Summary.

Producer gas	$88,000.00
Natural gas	12,000.00
Fuel oil	32,500.00
Hand-fired coal	20,000.00
Powdered coal	78,000.00

Summary.

Total operating charges per year for each plant:

Taxes and insurance at	1%
Interest	6%
Depreciation	8%
Total	15%

Producer Gas.

Fixed charges—15% of $88,000	$ 13,200.00
Operating charges—$536 × 300 days	160,860.00
	$174,060.00

Natural Gas.

Fixed charges—15× of $12,000	$ 1,800.00
Operating charges—$438 × 300 days	131,400.00
	$133,200.00

Fuel Oil.

Fixed charges—15% of $32,500	$ 4,875.00
Operating charges—$907 × 300 days	272,100.00
	$276,975.00

Hand-fired Coal.

Fixed charges—15% of $20,000	$ 3,000.00
Operating charges—$564 × 300 days	169,200.00
	$172,200.00

Powdered Coal.

Fixed charges—15% of $78,000	$ 11,700.00
Operating charges—$276 × 300 days	82,800.00
	$94,500.00

Summing up, although the first cost of a powdered coal is in excess of most fuel plants, the operation of it is much cheaper than any other fuel, for, by installing coal in your heating furnaces, the savings to be effected are as follows:

	Saved per year
Powdered coal vs. producer gas	$ 79,560.00
Powdered coal vs. natural gas	38,700.00
Powdered coal vs. fuel oil	182,475.00
Powdered coal vs. hand-fired	77,700.00

Results Obtained with Powdered Coal on Different Kinds of Furnaces.

Sheet and Pair Furnaces—Formerly burned 4,000 cubic feet of natural gas; now use only 300 pounds of powdered coal.

Formerly burned 600 pounds of coal, hand-fired.

Also have found that with powdered coal there is less percentage of wasters, that the rolls in the mills require less polishing and the plate requires less acid to pickle.

Annealing Furnaces—Natural gas requires 20 to 24 hours to bring furnace with charge up to a temperature of 1,600 deg. F. With powdered coal it requires 12 to 15 hours to do the same work.

These annealing furnaces all have pyrometers connected with them, and the readings show a variation of 1,600 to 1,640 deg. during the week's annealing.

Natural gas—14,000,000 cubic feet per month.

Powdered coal—525 tons of coal.

Tin Pots—Required 400 cubic feet of natural gas per hour. Now takes 26 pounds of powdered coal.

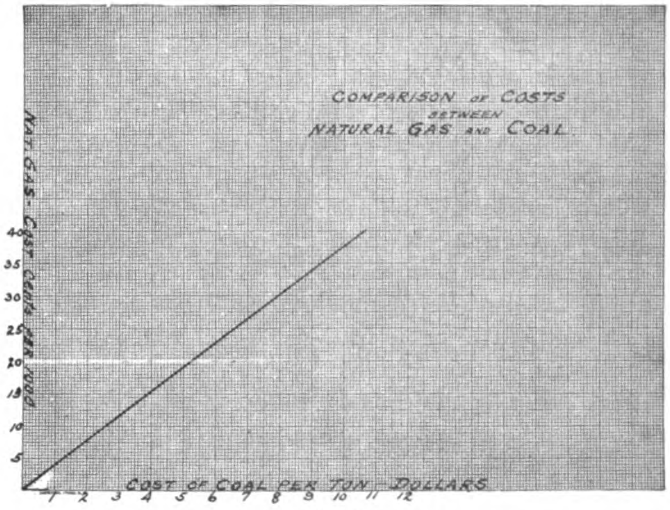


Fig. 1.

Rivet Furnaces—Requires 15 to 20 pounds of powdered coal per hour.

Continuous Billet Heating Furnaces—Capacity 28 tons per hour—160 pounds of coal per ton—4 x 4 x 55 inch billets.

Bloom Heating Furnaces—Requires 100 to 150 pounds of coal per ton of hot blooms 8 inch x 8 inch x 10 feet 0 inch long. Capacity of furnace up to 30 tons an hour.

Drop Forge Furnaces—Formerly required 7 to 10 gallons of fuel oil per hour, according to size of furnace.

Now takes 70 to 100 pounds of powdered coal per hour, giving better, softer and less oxidizing heats.

Welding Furnaces—Can be brought to a heat from a cold furnace in 20 minutes with powdered coal, and after testing the welds made with powdered coal, it has been found that the weld is stronger. Just the reverse has been found with welds made with fuel oil.

Open hearth Furnaces—Formerly required 70 to

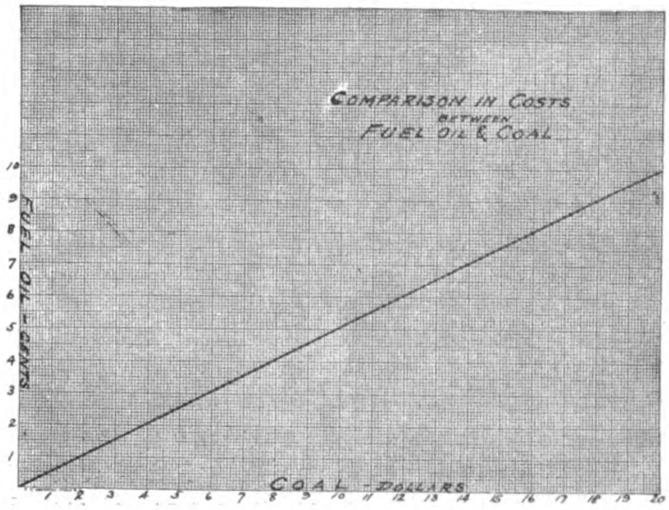


Fig. 2.

90 gallons of oil per ton of steel heated.

Now requires 600 pounds of powdered coal.

Furnaces are running up to 150 heats before being shutdown to clean out checkerwork.

Nut Furnaces—With natural gas it takes just twice the time to heat rods and bars that it does with powdered coal.

Fig. 1 is a graphic chart showing the comparison of costs between natural gas and coal per ton. This chart is based on 75 pounds of 13,500 B. t. u. coal being equal to 1,000 cubic feet of natural gas containing 1,000 B. t. u. per cubic foot.

Fig. 2 is a graphic chart showing the comparison of costs between fuel oil and coal per ton. This chart is based on 10 pounds of 14,000 B. t. u. coal being equal to fuel oil containing 19,000 B. t. u. per pound or 140,000 B. t. u. per gallon.

The Ash Question—The presence of inert impurities in the fuel has not much effect. Only combustibles will burn; the non-combustibles, if inert, do not necessarily affect the operation of the furnace. Their effect is in the reduced amount of useful work obtained from a dollar's worth of fuel. Coal has been burned which contained up to 52 per cent ash. Good performance depends not so much on the per cent of ash or the heat value of the fuel, as upon dryness, fine grinding, a hot fire and the proper air supply.

But while the absolute amount of ash in coal may have only minor influence on its suitability for use when powdered, the quality of the ash is all-important.

With the ordinary method of burning coal under a steam boiler, the grate (with its bed of solid incandescent fuel more or less encumbered with ash and clinker) offers a considerable, a varying and an irregularly distributed resistance to the passage of air, rejects the incombustible residue with some difficulty, and allows some of the unburned fuel to sift to the ashpit or to be fused in with the clinker. With powdered coal burned in suspension, many of these difficulties disappear. There still remains, however, the difficulty of getting rid of the incombustible. This is done by at least 25 per cent of the ash content passing up through the stack with the gases and the remaining being deposited as slag in the combustion chamber, where it can be easily removed.

There is a common impression that the fine ash, passing over the work to be heated will be deposited to some extent upon the work and cause trouble, but it is the writer's experience in heating sheets for tin plate, that the ash has been found to be absolutely no factor and is not a detriment at all. This has been true in all cases of heating by powdered coal in all kinds of furnaces.

In small furnaces having no stacks it is good practice to construct exhaust hoods in front of each furnace and connect these to an exhaust system, using either a fan to discharge the gases and fine ashes into a collector, or natural draft to discharge them into the atmosphere, where the fine ashes will float away for miles.

Explosions—Much has been said of the danger of explosions accompanying the use of powdered coal. This is partly due to confusion with dust explosions in coal mines. The latter are due to the floating dust in the air in a confined space. The department of a powdered coal plant, in which the coal grinding is done is usually a fit place for an explosion, for it is almost impossible to grind coal without having some dust escape. There is, on the other hand, plenty of opportunity for change of air, which should minimize the possibility of explosions. Dust is overcome by the use of a grinding system employing exhaust fans. With the atmosphere saturated with coal dust and all crevices and ledges filled and covered with fine particles, there would seem to be every chance for an explosion. Yet the author has not heard of but two instances where explosions have taken place in the grinding room. There have been cases where a match or spark, coming in contact with some of the dust lying on a ledge has started a fire, but this scarcely constitutes an explosion. The remedy seems to be to keep the grinding room as clean as possible, forbidding the use of any open lights or fires.

W. D. Wood, in the "Railroad Gazette" of July 18, 1913, says of powdered coal explosions:

"I can say positively that there is absolutely no danger of explosions of powdered coal where ordinary, sensible precautions are observed. The writer has worked in cement mills and has burned powdered coal himself, and knows whereof he speaks. In the first place, powdered coal, when in storage or in bulk, or while being blown into the furnace, does not explode. It may puff, or flare back slightly, when starting up a furnace, if there is not enough draft, but even this is preventable.

"As to storage and burning, coal pulverized and stored in tanks is 100 per cent less liable to explosion than oil. It sometimes catches fire from spontaneous combustion or otherwise, and nothing happens any more than what would happen if a pile of slack coal should catch fire. It is not even necessary to shutdown. All that is necessary is to keep right on drawing it off in its semi-burnt state, cutting off the supply to the bin that is on fire, and burn it until it is all out of the tank, when a new supply may be put in, if the tank has not become heated. Care must be taken to see that none of the burnt coal remains."

Much has been said concerning the relative merits of the fuels discussed in this article which has led to misunderstanding, but it is hoped that the figures of cost of installation and operations herein compiled will be of assistance in deciding the fuel to be used in new installations as well as in rebuilding old installations.

Principal Changes in Blast Furnace Lines

Development of Furnace Lines During Past Few Years—Form of Protection of Stock Lines—Brick Work in Thin Lined Furnaces — Discussion of Cooling Plates.

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PART I.

Anyone making a careful study of the results achieved in the modern blast furnace plant would find it very difficult to assign attainments to any one particular line of designs, control or operation.

Blast furnace design has not reached a point of mathematical precision where amount of product can be figured within a small percentage of the theoretical desired, such as the mechanical and electrical engineers might do with the designs of large turbines, generators, etc. We often hear of a turbine design projected for thousands of horsepower for a working machine, with results that are very close to contract figures.

Not so with most metallurgical furnaces; particularly the blast furnace which no one yet has been able to radically alter in its process methods. Most results that are gained may be shown by figures of comparatively small percentages, and these as a rule have been developed over a long period of years of experimentation. Very often these periods represent only cycles in the efficiency curves.

To reach the point of efficiency, production and smoothness of operations, which is the aim of all, certain lines of procedure must be observed in the assembling of the different ends to get the desired results. One would classify these under the four general heads as follows:

1—Perfect knowledge of the material must be had beforehand, both physically and chemically, and these should have as much regularity as possible.

2—Proper designs of apparatus.

3—The organization must be keyed up to the highest point of skill and fully educated in the program to be pursued and in the results desired. The modern blast furnace is no longer a one-man proposition in its regulation.

4—The mechanical equipment must keep running with a smoothness that will not hold back any of the other developments. Very often this is found to be a weak point in the working out of new designs in the metallurgical end.

No one of these points can be neglected if the whole proposition is to be rounded out.

Up to the of 1900, the majority of the furnaces of the steel making companies had been served with a superior grade of coke from the old Connellsville basin, with a fixed carbon from 89 to 90 per cent, ash as low as 10 per cent, and sulphur around .8 per cent.

They had been working on ores which caused very little inconvenience, the metallic contents running high with small variations, and we find in parallel the use of all facilities that may have been at hand to give good tonnages, coke practice and general efficiency. This period continued until we have the climax in the big production of the Duquesne and Edgar Thomson furnaces. (These two are named because they are most generally known.)

From 1905 and for the next five years there is a quick change in the physical characteristics of the materials used. Coke for the most of the furnaces was made from coal that was not quite as good as that of the old Connellsville basin. As a rule it was soft, small and carrying lower fixed carbon and higher ash.

Dry Analysis of Fuel of a Representative Company.

Year	Ash	Fixed Carbon	Sul.
1900	10.74	88.04	.93
1901	10.79	89.12	.86
1902	11.62	88.20	.86
1903	12.98	86.52	.86
1904	11.33	87.50	.86
1905	12.12	86.69	.85
1906	12.41	86.32	.85
1907	12.04	86.61	.83
1908	12.44	86.62	.84
1909	12.71	85.78	.87
1910	13.44	85.83	.94
1911	13.01	85.75	.91
1912	12.79	85.75	.94
1913	13.51	85.48	.95
1914	12.80	85.00	.90
1915	12.50	86.00	.94
1916	13.52	85.00	.99
1917	13.40	85.90	1.07

The Mesabi ores were mixed in higher and higher percentages, as shown in table following. The physical properties of these ores changed from a fairly coarse mixture to one that might carry 15 per cent through the 100-mesh sieve.

This variation in material naturally required different methods of operation. Irregularities developed which led to a great decline in the efficiencies attained by the representative plants of the country. Many of us are familiar with this decline and it was emphasized by low tonnages, high coke consumption, greater losses, due to making more flue dust, and the attending troubles incidental to irregularity of furnace operations.

The most pronounced changes were the lowering

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of the blast temperatures, more irregular movement of the furnace, higher flue dust production, a large amount of accidents, high coke consumption, etc. This period would show an attempt to overcome lower production by increasing the blast volume, which in itself is liable to counteract the best results that may have been obtained under certain conditions. Attending this high wind usage we find a quicker deterioration of furnace lines which in itself alone accelerated bad practice.

In the meantime the consumption of Mesabi ores rose in some representative companies from 59 to 81 per cent. In some cases and for short periods this rose to 95 per cent.

Table Showing Mesabi Increase of a Representative Company.

Year	Per cent
1907	59.5
1908	59.4
1909	63
1910	71.4
1911	62.4
1912	55.6
1913	61
1914	65.4
1915	71.6
1916	74.5
1917	81.9

The mere tabulation of sieve tests of percentages of Mesabi used would be a small part of the actual physical change that took place. Criticisms of like nature may be applied to what was also termed "old range ore." It became very different in texture, as the separate seasons opened up, no longer did we have the lumpy ores of former years gone.

From 1905 to approximately 1910 we find no lasting development which called for any upward turn to better general results, with possibly the exception of an old furnace here and there. In the year of 1910 a marked change was made in the development of the hearth diameter, as for instance, in the blast furnaces of the South Chicago plant of the United States Steel Corporation. With permanent results being accomplished it blazed the way to apparent better efficiencies.

About this time we also find a systematic campaign going on for an improvement in the quality of the fuel and fluxes used in the blast furnaces. This move in itself means quite a lot of time and study and should be given due credit. These developments gradually spread through the corporation's plant and later through the line of independent furnaces, making all grades of irons.

It can be noticed that as furnace operations commence to be smoothed out, we find large tonnages, small losses, gradual lowering of the coke consumption, and particularly the use of higher hot blast temperatures at the representative larger plants. In a great many cases these heats rose from 750 to 1,100 deg. F. average temperature lines. Anyone acquainted with these different developments knows the difficulties that attended this progression. The production of flue dust decreased from around 500 to 200 pounds per ton of metal, showing much smoother operations. This turn in the development came to a climax in the years 1915-16, where we find supporting the country's output of steel, a phenomenal blast furnace operation at quite a number of plants, showing an average line of increased production, lower coke practice, etc., for the country at large. The highest of these average lines for the year were obtained at a number of plants as can be noted from table following.

Plant	Number of fces.	Aver. tons daily for the year	Coke consumption
1	11	539	1878
2	1—(2 fces. in group)	608	1854
3	4	535	1867
4	4	526	2197

All these plants worked on a different kind of coke, fixed carbon, etc. The rounding out of these developments in most cases is all the more interesting because they were accomplished when using material that in former years gave only ordinary practice, and one will have to study what change took place in furnace design to make any conclusions.

Since the year 1917 the furnaces of the country have been so upset by irregular operations, material, etc., that this time should not be taken into consideration.

Development of Furnace Lines During the Past 10 or 12 Years.

In going into the analysis of what may have likely aided this increase, the subject of the development of the lines of the furnace with attending influences is interesting and broad. The subject will be divided into four general classifications:

1—What has been the development of the furnace lines, thickness of the brickwork and how the lines are maintained above the mantle.

2—Special study of the increased diameter of hearths, steeper angles in the bosh, how the bosh is maintained, showing results.

3—How has the change of bosh influenced the carrying of hot blast temperature.

4—Discussion on how poor material is being used and what results are being obtained.

The term "lines" of a blast furnace is commonly understood to be internal shaping of the brickwork, expressed in dimensions of feet, inches, degree of angles, etc., and is the bounding line of brickwork, etc., called linings. We should divide the lines of the furnace into sections of the heights, which may be termed:

1. The throat.
2. The middle section.
3. The bosh.
4. The hearth.

The sections are subjected to different degrees of heat and wear, and are constructed differently in order to suit the best purpose. Before entering into results obtained in any furnace it is well that we should study the details of these parts for shape, size, method of holding, etc.

1—The Throat.

Starting at the top of the furnace we encounter a section that is subject to a comparatively low heat, but is given rough usage, due to the abrasion of material first coming in contact with the brickwork, and being deflected to move in a vertical plane downward. In the large furnaces of the steel making plants this would likely appear as shown on sketch No. 1. (All sketches are shown on pages 292 and 293.)

For years there has been no great variation in the shape or size of this part of the lines. Its protection is one of greater interest.

Forms of Protection of Stock Lines.

Some furnaces are built without any protection, the bricks being held firmly together with a small percentage of cement, and good results have been obtained.

Sketch No. 2 is a section of the upper wall of a furnace which produced 670,000 tons of metal, with a coke consumption of 1,925 pounds per ton of metal, with no renewal of walls. Some furnace plants renew these during the campaign, others find it gives good results for quite a length of time.

On sketch No. 3 there is shown a successful method employed by some of the large plants of the country. It consists of steel sections tied back to the shell.

Sketch No. 4 is one of the most common designs of stock line protection, and consists of cast iron sections imbedded directly in the brickwork. In practice, if they are put in correctly, their life is as long as that of the average lining.

Sketch No. 5 shows a method that also has given good results, and consists of steel bands imbedded in the brickwork.

In both methods Nos. 4 and 5 it is necessary that perfect bonding be made with the refractory brick in order to hold.

The loss is quickly felt around this section, in case something is misplaced.

These protection plates are variable for different distances above and below the stock line level. If they are placed too far below they may go rather early in the campaign, owing to some local heat action which would destroy them. It should be borne in mind that irrespective of the distance protected by them, the brick wall will cut away badly just below the points unprotected.

Sketch No. 6 shows large cast iron or steel sections with water pipe inserts. Their use is not general, but they have given very good results.

Stock line protection is of the highest importance, and unless we maintain a definite shape, bad furnace operation is experienced at all times, but when it is maintained properly good practice can be gotten, even though other parts of the lining may show great weakness. Too much stress cannot be placed upon a proper protection.

2—The Middle Section.

In the period of large blast volumes a rapid deterioration of the middle parts of the refractory lining causes considerable effort to be made in the holding out for longer life of lining. This brought about several modifications in the way of cooling above bosh lines.

The wide difference in the construction of a blast furnace comes at a line known as the bosh, and is a point in the temperature scale of the whole process where there is a change in the state of the materials.

This in mathematical measurements is approximately 12 to 14 feet above the point of the blast entrance, and on analysis appears to be the same in all furnaces of different sizes and dimensions. Here we find a fairly high degree of heat given by most authorities, and substantiated by rough checking to be somewhere between 1,850 to 2,000 deg. F. This degree of heat causes but little change in the physical state of the materials charged, only a slight softening. One is inclined to think in ordinary working conditions there should be but little fusion at this point. When there is a fusion it makes its appearance in the form of the furnace hanging up. This degree of heat would not ordinarily injure any of the refractory materials used in construction. However, this middle section is subjected to such an erosion, chemical reaction, pressures and swelling of the charge that it is quite independent of so moderate a temperature. The wearing away of the refractories is proportionate in all heights of furnaces, and follows the chemical changes closely.

Sketch No. 7 is taken from the works of L. Bell (Sir Isaac Lowthman (?), and the early investigations of this observer remain unrefuted.

Before 1905 the average brickwork in most steel works' blast furnaces approached closely to 60 inches at the mantle and was constructed sometimes in two walls, as shown in sketch No. 8.

This was later changed to a method as shown in Sketch No. 9.

About this period there were some remarkable tonnage records turned out on the lining life, with fair coke results, although efficient coke practice was no doubt sacrificed for longer tonnage records. Some of the large tonnages produced on these lines would as follows:

Plant No. 1	1,296,000 tons
Plant No. 2	1,202,000 tons
Plant No. 3	1,250,000 tons
Plant No. 4	1,327,000 tons

This was following closely after the English practice of very thick walls, but a more rapid driving coupled with the finer Mesabi ores caused the thick walls

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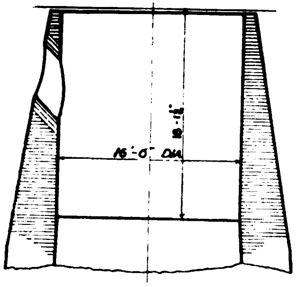
SKETCH No 1.



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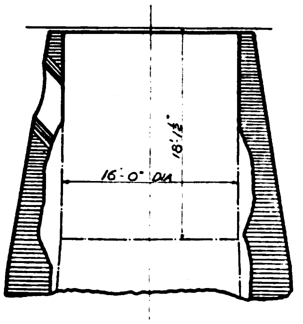

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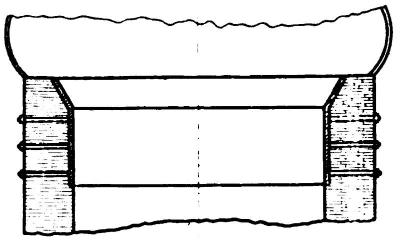

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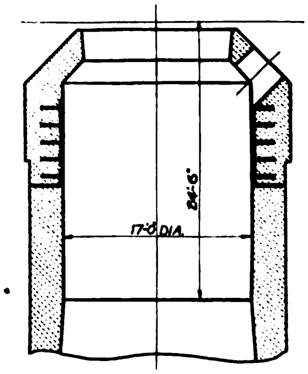

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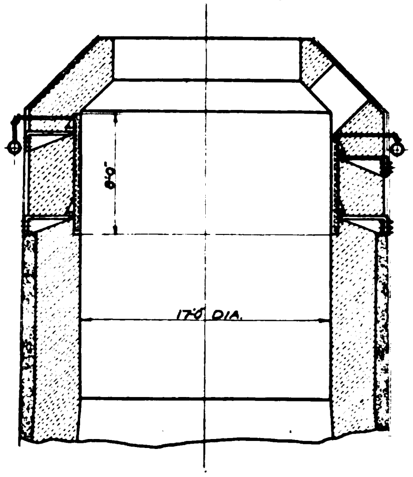

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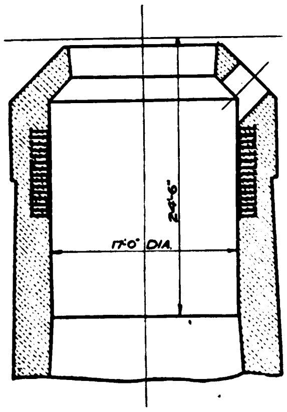

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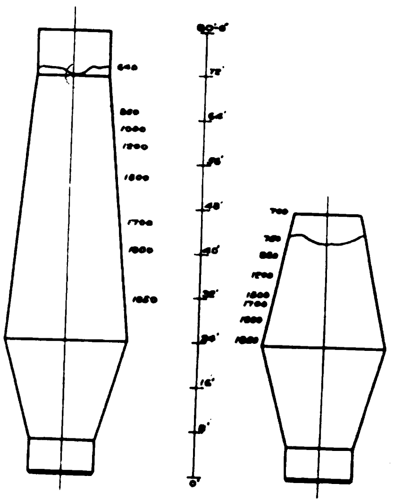

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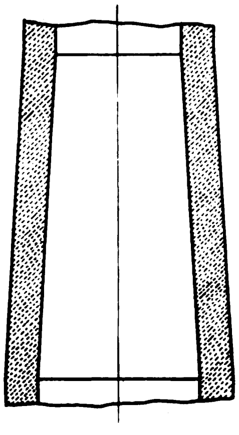

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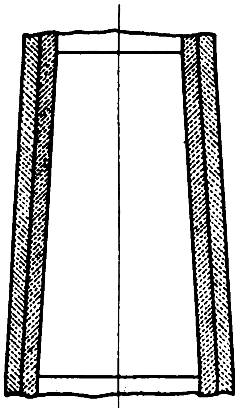

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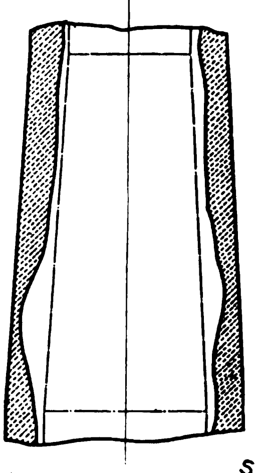

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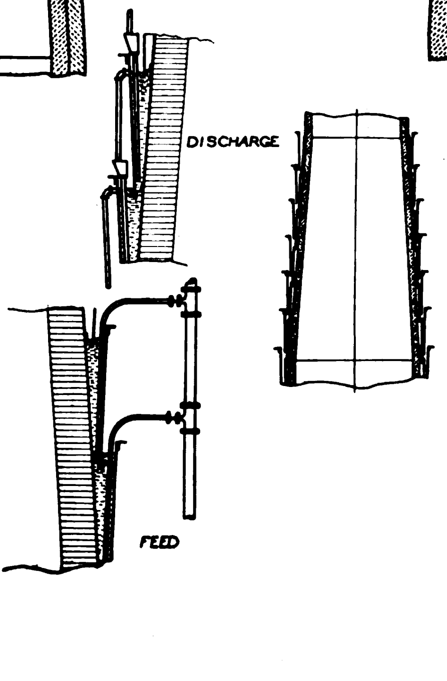

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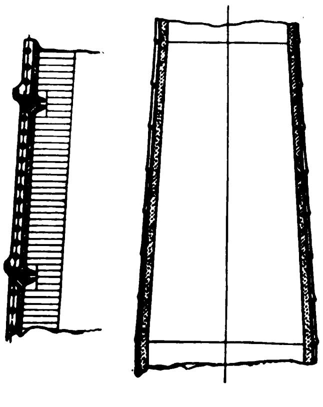

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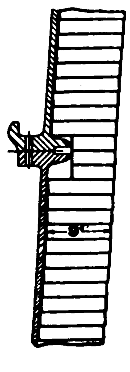

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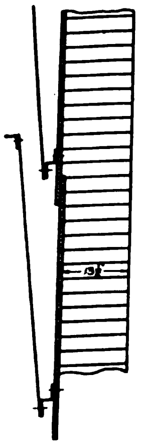

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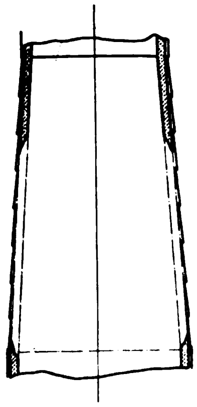

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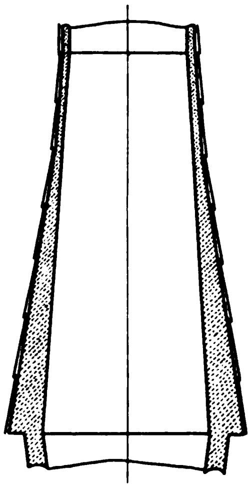

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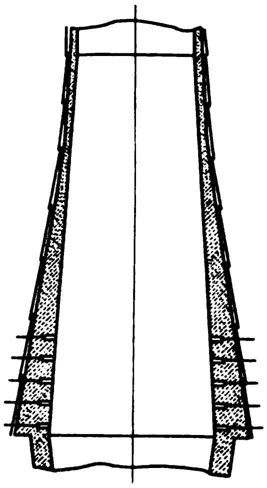

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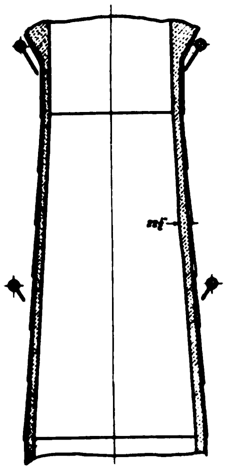

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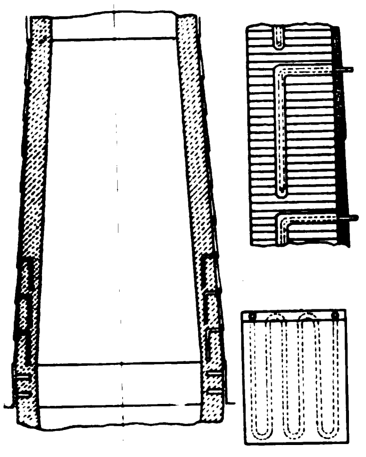

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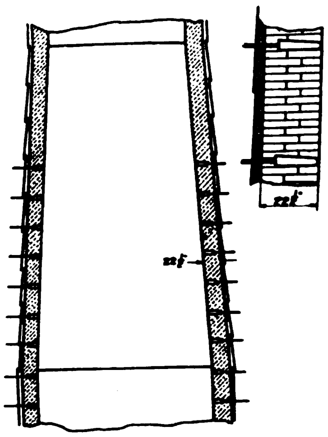

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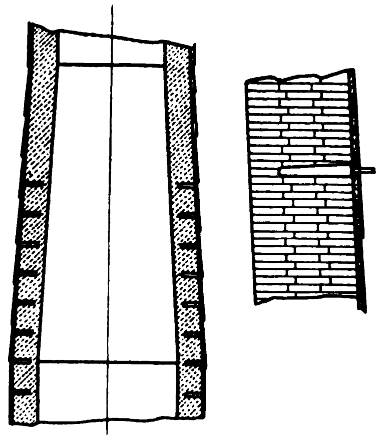

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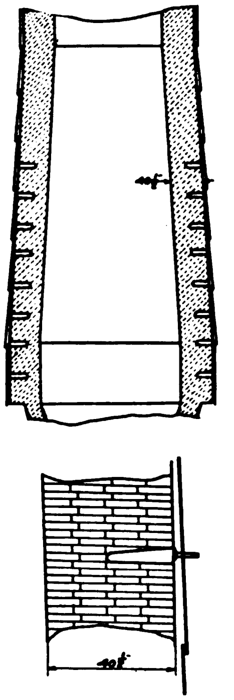

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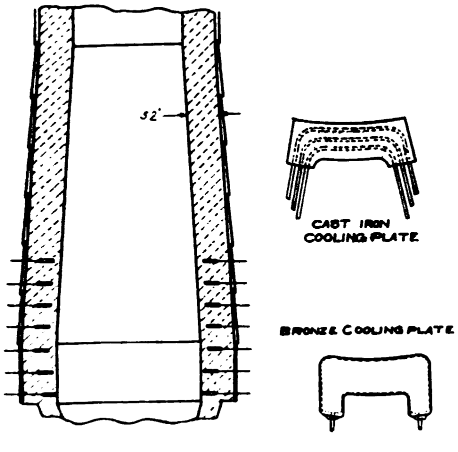

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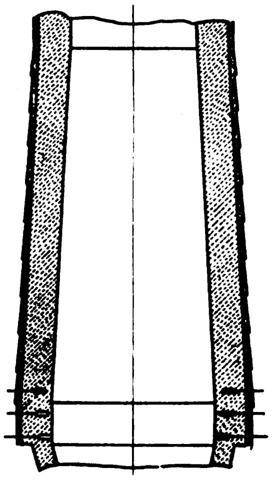

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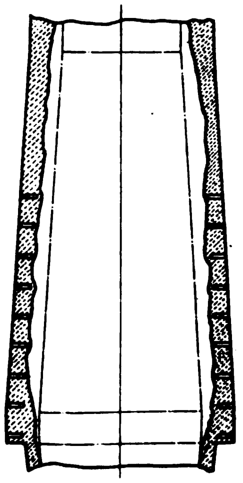

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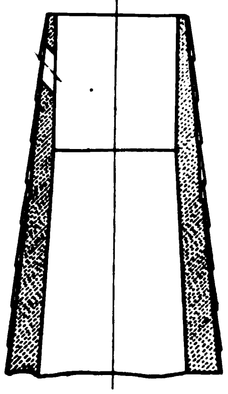

to be gutted badly. Also, a saving was attempted on refractories by the grinding of old material when making brick for the new linings. All these resulted in more frequent tearing out and rebuilding, the idle time percentage being considerably increased. In the tearing out of the thick walls it was noticed that a large percentage of the brick was still good.

A composite drawing of the wornout lines of a furnace of this period would look like sketch No. 10.

Thin Lined Blast Furnace.

About 1906 the thin blast furnace made its appearance from Europe. Great results were anticipated for it in the reduction of the time necessary for the relining period, and with the hope that by cooling the surface the blast period would be indefinitely prolonged. It was also thought that this lining could be subjected to conditions of operations which were impossible with the thick lining. Visions were had of its ability to make large tonnages and constant coke practice.

The United States Steel Corporation, showing its usual method of progression, had these furnaces built in four districts in order to get the different results under different conditions of management, material and operating conditions.

In each case the brick was fitted tightly against the steel shell, the outside of this shell being cooled with water.

Sketches Nos. 11 and 12 will illustrate methods of construction.

Sketch No. 11 shows rolled steel sheets riveted together and buckets fastened to the shell, the water for cooling overflowing from one line of buckets to those below. This was the early type.

Sketch No. 12 shows cast steel sections bolted together, with water running all the way from the top to the bottom of the furnace, and was tried out only at one plant. It is still in use with only slight changes.

The experiences of the operating people with these thin lines were many. The greatest difficulty was encountered in keeping the water from going into the furnace. Quite a number of these irregularities were overcome from time to time.

Thin Lined Furnace with 9 inch Brickwork.

Sketch No. 13 shows a single 9-inch brick used with a thin clay as a binder, butted tightly against the shell, and could be constructed in a very short space of time. It being a matter of simply laying the brick in; very little cutting or chipping was necessary.

The data following will show some of the work of these lines:

Plant	Campaign	Tons per day	Total production	Coke per ton of metal
1	1	435	175,000	1,948
1	2	418	218,000	2,161

In the thickness of brick the life was found to be too short for a commercial proposition, owing to the fact that some other sections of the furnace were expensive and took time to rebuild. Practically all these furnaces have since been relined with slightly thicker brickwork.

Thin Lined Furnace with 13½ inch Brickwork.

Sketch No. 14 shows the 13½ inches of brickwork which was next used, laid in thin clay and butted against the shell. By increasing this thickness 4½ inches better results were at once obtained, and operations were smoother for a longer period.

Some data on these lines would read as follows:

Plant	Campaign	Tons per day	production	Coke per ton of metal
1	1	500	299,000	1,954
1	2	481	243,000	2,136
1	3	526	454,000	1,934
2	1	531	295,000	2,076
2	2	497	217,000	2,111
2	3	522	222,000	2,050
2	4	500	200,000	2,144

At plant No. 1 the tonnage gained on the increased thickness of 4½ inches of brickwork was 136,000 tons, and the average coke consumption throughout the lining life was also better.

It should, however, be noted that the 9-inch lining had to suffer for all the mistakes made in construction. The 13½-inch lining following, necessarily profited by these corrections. Some of these construction difficulties were interesting and were seen in the form of cracking of the middle section, cracking of the shell even with water held against it, as in the bucket type.

At first angles were also used to support the brickwork, these being done away with at some places.

This type of furnace was thought to be particularly adapted to the making of ferro-manganese, ferrosilicon, spiegels and other high coke irons. They lasted fairly well in this work but did nothing to uphold any unusual claims. As a rule they would be blown out on account of too much water getting into the stacks. It was noted that these furnaces first became weak in the same relative position as the thick lines.

Sketch No. 15 will show brick comparatively good 30 feet down, after the furnace had produced over 230,000 tons, and was blown out on account of too much water getting into the stack.

It is interesting to compare the work of these furnaces for certain periods, with thick lines, under the same management, and it is observed that while the thin lines were in fair shape the work was almost equal.

The following table shows thin lined furnaces compared with others in the same group during period of runs:

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Plant	Furnace	Thickness of wall	Average daily tonnage per year	Coke consumption per ton of iron
1	1	Thick wall	533	2,056
1	2	Thick wall	535	2,010
1	3	13½"	510	2,095
			(Monthly run)	(Monthly run)
2	1	Thick wall	543	1,702
2	2	Thick wall	545	1,742
2	3	13½"	537	1,904
2	4	Thick wall	567	1,820

The general comment on these furnaces, is that there have been none erected in the last few years. This is in spite of the small sum necessary to cover cost of relining, and idle time having been reduced to as low as two weeks between blasts. Those concerned in their operations have favored somewhat thicker lines. Several of this type will be modified, as shown in sketches Nos. 16 and 17:

The method of sketch No. 16 should prolong the life of the lining up to theoretical eliminations of 600,000 tons.

The most serious objections to the construction of the thin lined blast furnace is that once we have the heavily constructed shell the lining cannot be altered quickly, unless a considerable time is taken to remodel the shell in some manner. If it were found practical to assemble other parts of the lining as quickly as is done in the section from the mantle upward, there would still be high hopes entertained for the thin lined blast furnace.

Twenty-two and One-half inch Lining.

With the experience obtained on the thin lined furnaces of 9 and 13½ inches of brickwork, modifications have developed which call for lining 22½ inches in thickness, made in two bricks, butted tightly against the steel shell and sprayed with water when necessary.

This construction can be noted on sketch No. 18.

An accurate measurement of the wear was taken on this furnace after it had produced 220,000 tons of metal, it being out of blast on account of no demand for the product. It was found that the lining had only worked back a few inches, and it was put back into blast after standing two years, and has produced to date 530,000 tons of iron.

Its record during this period compared most favorably with the thicker lined furnaces of the same group, no trouble being experienced with the shell taking water, etc.

However, similar comments can be made on the 22½-inch lining, as was noted on the other thin lines; that is, the lining cannot be changed widely from what is originally planned, unless it is decided to make the volume of the furnace smaller.

Cooling by plates Inserted in the Lining.

We now turn to another form of holding the lining above the mantle section. In this method cooling plates are securely buried in the brickwork of different thicknesses, and are usually in position for the lining's life. The methods of insertion and distribution over the stack area vary widely. Their usage has in a good many cases reduced the thickness of the brick lining. In other cases, however, we find that the lining is made as thick as formerly.

"L" Type Cooling Plates in 31½-inch Lining.

This is usually a large cast iron plate, with coils of pipe imbedded. Sketch No. 19 will give the method of construction.

This method has not been used very extensively, but in the plant where its service has been continual, we have the following data:

Furnace	Daily average production for year	Coke consumption per ton for year	Total tons produced
1	518	2,112	783,500
2	518-6/10	2,128	701,667

Twenty-two and One-half inch Lining with Bronze Cooling Plates Placed Flush with Face of the Brickwork.

This method of protection is used in a few places. Results experienced do not give the best efficiencies, nor was there any great extended life of blast by the use of this method.

Thirty-six inch Lining with Bronze Cooling Plates.

This method is sometimes used with the plates flush with the edge of the lining, and in other cases placed a few inches back. We know of cases where this has made 800,000 tons of very fair practice.

Forty and One-half inch Lining with Bronze Cooling Plates.

This thickness of lining is a little more popular than some of the others mentioned, and has given good results. In most of the cases we find that the plates have been placed back of the face of the lining. Some average results on this type of lining are shown in the following table:

Furnace	Average daily tonnage per year	Total tons on lining at that time
1	530	559,000
2	507	498,000

Some low coke and good tonnage figures have been obtained with these lines.

Fifty-two inch Lining with Bronze Plates.

This is the most popular of all lining cooling by the plate method, and we find that as much as 22 inches of brickwork is in front of the plates. (See sketch No. 23.) The work of these furnaces would be typical, as shown in the table following:

Plant	Furnace	Best daily production for month	Tons produced on lining at this period	Coke consumption on that tonnage
1	1	567	100,000	1,904
1	2	520	....	1,942
2	1	669	600,000	.....

It is very clearly demonstrated that the placing of the plates back from the face of the brickwork adds very much to the smoothness of the working of the furnace. In the plants where this is used, their lining life is extended considerably. The coke practice is very much influenced toward the end of the lining life.

In place of using bronze plates, as is shown by the foregoing sketches, cast iron coolers with pipe inserts have been used. They have not been as successful as the bronze effect, however, it being noted that they burn away much quicker, and cause more irregularity of the working of the furnace after being in blast for a time.

Quite a number of places have not carried this cooling to any extent, as noted in some of the other sketches, but preferred to give only a small cooling space, a few feet above the mantle, as can be noted in sketch No. 24.

This has not been of much advantage as far as we know, owing to the fact that this lower part, cooled by these plates, does not give away nearly so frequently as the other parts of the lining.

In some cases this arrangement caused trouble, where the coolers failed during the early part of the campaign, and had to be abandoned.

Although the cast iron coolers are much cheaper, there is no comparison in the results obtained when using the bronze, owing to the fact that very few bronze plates are apt to fail.

Where plates have been used for prevention of wearing in the upper lining, the most successful campaigns have been experienced with the plates set back from the face of the lining at the time the furnace was blown in. The wearing away of the lining between the cooling plates becomes very irregular towards the last part of the blowing.

Sketch No. 25 will show a composite drawing from several blow cuts.

Furnaces of this type work very irregularly when old. The general comment on this style of operation is that as a whole this type of furnace has not produced the highest daily tonnage, nor the lowest coke consumption, but they show some very long lining periods. It is questionable how long a furnace should run for the best of efficiencies, because an extended lining life may not always mean the best results that are possible.

A Summary of Iron and Steel Processes

A Sequence Showing the Steps from Ore to Finished Products, Giving Typical Analyses, Also Official Pig Iron Prices Now in Force in the United States.

By ELIOT A. KEBLER.

From Ore to Finished Product.

Iron Ore	Contains Iron and Oxygen and impurities.	
Iron Ore	Smelted in a Blast Furnace, removing Oxygen and part of impurities and adding Carbon, makes -	**Pig Iron**
Foundry Pig Iron	Melted in a Cupola and cast into molds makes	**Iron Castings**
Iron Castings	Made from Malleable Pig Iron and heated in Scale, make	**Malleable Castings**
Grey Forge Pig Iron	Melted in a Puddling Furnace, then balled, squeezed and rolled, makes	**Muck Bar**
Muck Bar	or Wrought Scrap cut into short lengths, piled, heated and rolled, makes	**Wrought Iron**
Muck Bar	Treated as above and rolled into strips, makes	**Skelp Iron**
Skelp Iron	Bent into the shape of tubes and welded, makes	**Iron Pipe**
Muck Bar	Or Steel melted in a Crucible with Charcoal, makes **Carbon Steel, Tool Steel or**	**Crucible Steel**
Muck Bar	Or Steel treated as above, with Tungsten added to raise the temperature at which it softens, Chromium to give toughness, and Vanadium, Titanium, Aluminum or other metals to improve the quality, heated to a high, then to a lower heat makes	**High Speed Steel**
Bessemer Pig Iron	Direct from a Blast Furnace or melted in a Cupola, poured into a Converter, with air blown through it to burn out the impurities makes	**Bessemer Steel**
Pig Iron	Molten, or in pig, with or without Scrap, when purified in an Open Hearth Furnace makes	**Open Hearth Steel**
Low Phos. Pig Iron	Treated as above in an acid (Slica or Sand) lined open hearth furnace makes	**Acid O. H. Steel**
Basic Pig Iron	Treated as above in a basic (Dolomite) lined furnace to remove Phosphorus makes	**Basic O. H. Steel**
	With only about 1-10 of 1% impurities is called by various trade names, such as **Toncan Metal, Genuine Open Hearth Iron** and **American Ingot Iron.**	
	Vanadium, or Manganese (over 7%), Titanium or Nickel Steel is made by the addition of these metals, all being called	**Alloy Steels**
Steel	Purified in an Electric Furnace, makes	**High Grade Steel**
Steel	Is cast into ingot molds usually about 19 in. sq. and about 6 ft. long, making	**Ingots**
Ingots	Are rolled into	**Blooms**
Ingots	Are rolled into	**Rails**
Ingots	Are rolled into	**Structural Shapes**
Ingots	Are rolled into	**Slabs**
Steel	Treated in a furnace and other metals added makes	**Tool Steel**

Slabs	Are rolled into	**Plates**
Ingots	Are rolled into	**Sheet Bars**
Sheet Bars	Are rolled into	**Sheets**
Sheets	Are cold rolled and stamped into	**Forms**
Sheet Bars	Are rolled into	**Black Sheets**
Black Sheets	Cleaned and coated with Spelter (Zinc) make	**Galvanized Sheets**
Black Sheets	Cleaned, cold rolled and coated with Tin make	**Tin Plate**
Black Sheets	Cleaned, cold rolled and coated with Lead and Tin make	**Terne Plate**
Blooms	Are rolled into	**Billets**
Billets	Are rolled into	**Bars & Small Shapes**
Billets	Are rolled into	**Steel Skelp**
Steel Skelp	Bent into the shape of tubes and welded makes	**Steel Pipe**
Billets	Are pierced, rolled and drawn through dies, making	**Seamless Tubes**
Billets	Are rolled into	**Rods**
Rods	Are drawn through dies into	**Wire**
Wire	Is made into	**Nails and Fencing**
Rods	Are headed into	**Rivets and Bolts**
Rods	Are welded into	**Chain**

ANALYSES.

Lake Superior Iron Ores (Natural Condition).

Brand	Range	Loss on ignition	Moisture	Iron	Silicon	Sulphur	Phosphorus	Manganese
American	Marquette	.93	7.72	54.29	10.61	0.118	0.025	0.25
Montrose	Gogebic	1.29	11.14	54.07	6.92	0.017	0.020	0.34
Dover	Mesaba	3.89	12.73	51.01	7.22	0.018	0.064	0.56
Republic Basic Lump (for open hearth)	Marquette	0.18	0.25	63.94	6.22	0.008	0.060	0.04
Beaver (Puddling Fce. Fix.)	Mesaba	3.36	12.41	53.57	3.80	0.011	0.069	0.38

Pig Iron—Standard.

	Silicon	Sulphur	Phosphorus	Manganese
No. 2 Foundry Base	1.75—2.25	0.05 or less	As made	1.00 or less
High Phosphorus	1.75—2.25	0.05 or less	1.00—2.00	0.15—0.30
Std. Southern	1.75—2.25	0.05 or less	0.60—1.00	0.15—0.50
Higher Mn. Sou.	1.75—2.25	0.05 or less	0.40—1.00	0.50—1.00
Virginia	1.75—2.25	0.05 or less	0.60—0.80	0.60—0.80
Std. Northern	1.75—2.25	0.05 or less	0.35—0.50	0.50—1.00
Strong Foundry	1.75—2.25	0.05 or less	0.30 or less	
Basic (chill cast)	1.00 or less	0.05 or less		
Malleable	As desired	0.05 or less	0.20 or less	0.80 or less
Bessemer	1.00—2.00	0.05 or less	0.10 or less	
Low Phosphorus	2.00 or less	0.04 or less	0.04 or less	

Ferro-Manganese...... Manganese 70% or less—it was 80% or less.

Spiegel................ Manganese 16% or less—it was 18%—22%.

Iron Castings.

	Total Carbon	Silicon	Sulphur	Phosphorus	Manganese
Light	3.40	2.75	0.075	0.75	0.40
Medium	3.50	1.75	0.080	0.55	0.60
Malleable	2.50	0.75	0.070	0.19	0.25
Semi-Steel	3.30	1.30	0.075	0.40	0.45
Semi-Steel Shells	3.25	1.35	0.130	0.08	0.60

Wrought Iron.

Total Carbon	Silicon	Sulphur	Phosphorus	Manganese
0.06	0.15	0.05	0.20	0.05

Open Hearth Steel.

Use	Carbon	Sulphur	Phosphorus	Manganese
Welding and rivet	0.08—0.15	0.05 or less	0.05 or less	0.30—0.60
Case Hardening	0.10—0.20	0.05 or less	0.05 or less	0.30—0.55
Structural, boiler and flange	0.15—0.25	0.05 or less	0.05 or less	0.30—0.60
Forging and machinery	0.35—0.50	0.05 or less	0.05 or less	0.40—0.70
Spring	0.85—1.10	0.05 or less	0.05 or less	0.50 or less
Rails	**0.46—0.75**	**0.20 or less**	**0.04 or less**	**0.60—0.90**
Bessemer rails	**0.35—0.55**	**0.20 or less**	**0.10 or less**	**0.70—1.15**

Tool Steel.

	Carbon	Silicon	Sulphur	Phosphorus	Tungsten	Chromium	Vanadium
Carbon Steel	1.10	0.20	0.03	0.015	.....	....	....
High Speed Steel	0.55	Trace	0.012 or less	Trace	18.00	3.50	1.00

Steel Castings.

		Old Specifications.		U. S. Army, May, 1918.	
	Carbon	Sulphur*	Phosphorus*	Sulphur	Phosphorus
No. 1	0.35 or less	0.05	0.05	0.08	0.06
No. 2	0.35 or less	0.05	0.05	0.08	0.06
No. 3	0.35 or less	0.05	0.05	0.07	0.05

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* May now run higher.

OFFICIAL PIG IRON PRICES.

June 27, 1918.

Prices f. o. b. Furnace, Ton of 2,240 Pounds.

Foundry Iron.

Silicon.	Mn. 0.00 to 1.00	Mn. 1.00 to 1.50	Mn. 1.50 to 2.00	Mn. 2.00 to 2.50	Mn. 2.50 to 3.00	Mn. 3.00 to 3.50	Mn. 3.50 to 4.00
Under 1.00	$32.00	$32.50	$33.50	$34.50	$35.50	$36.50	$37.50
1.00—1.75	32.50 Base	33.00	34.00	35.00	36.00	37.00	38.00
1.75—2.25	33.00	33.50	34.50	35.50	36.50	37.50	38.50
2.25—2.75	33.50	34.00	35.00	36.00	37.00	38.00	39.00
2.75—3.25	34.50	35.00	36.00	37.00	38.00	39.00	40.00
3.25—3.75	35.50	36.00	37.00	38.00	39.00	40.00	41.00
3.75—4.25	36.50	37.00	38.00	39.00	40.00	41.00	42.00
4.25—4.75	37.50	38.00	39.00	40.00	41.00	42.00	43.00
4.75—5.25	38.50	39.00	40.00	41.00	42.00	43.00	44.00
5.25—5.75	39.50	40.00	41.00	42.00	43.00	44.00	45.00
5.75—6.25	40.50	41.00	42.00	43.00	44.00	45.00	46.00

Silvery

Silicon	Sulphur	Price
6.00— 7.00	0.05 or less	$41.00
7.00— 8.00	0.05 or less	43.00
8.00— 9.00	0.05 or less	45.50
9.00—10.00	0.05 or less	47.50
10.00—11.00	0.05 or less	50.00

Bess. Ferro-Silicon

Silicon	Sulphur	Phos.	Price
10.00—11.00	0.05 or less	0.10	$55.00
11.00—12.00	0.05 or less	0.10	58.30
12.00—13.00	0.05 or less	0.10	61.60
13.00—14.00			
14.00—15.00			

Gray Forge, Mottled or White	$32.00
Malleable	33.50
Basic	32.00
Bessemer, Silicon 3.00 or under	35.20
Bessemer, Silicon 3.01—3.50	37.20
Bessemer, Silicon 3.51—4.00	38.20
Bessemer, Silicon 4.01—4.50	39.20
Bessemer, Silicon 4.51—5.00	40.20

Low Phosphorus.

Phosphorus	Copper 0.04 and under	Copper 0.041—0.250	Copper 0.251—0.500	Copper Over 0.50
0.025—0.030	$56.00	$55.00	$54.00	$53.00
0.031—0.035	54.50	53.50	52.50	51.50
0.036—0.040 Base	53.00	52.00	51.00	50.00
0.041—0.045	50.50	49.50	48.75	48.00
0.046—0.050	48.00	47.25	46.50	46.00
0.051—0.055	45.50	45.00	44.50	44.00
0.056—0.060	43.00	42.50	42.25	42.00
0.061—0.065	39.50	39.50	39.50	39.50
0.066—0.070	38.50	38.50	38.50	38.50
0.071—0.075	38.00	38.00	38.00	38.00
0.076—0.100	35.20	35.20	35.20	35.20

Sulphur (In all grades).................................. 0.04 or under

Silicon (Add $1.75 for each 1.00% over 2.00%).......... 1.00—2.00

CHARCOAL.

Southern or Warm Blast.

Phosphorus, 0.40—0.60; Silicon, 2.00 or less.................... $43.00

(Add $1 for each ½ per cent silicon over 2.00 per cent.)

Cold Blast	80.00
Northern Semi-Cold Blast	55.00
Lake Superior	35.50

For iron averaging 1.25 per cent in silicon, with usual differentials.

Test on Rotary Blowers and Exhausters

Investigations of Effect of Pressure Drop Due to Friction in the Intake Pipe, Actual and Probable Delivery With Varying Speeds. Relation Between Quantity of Air Delivered and Blower Speed.

Tests to determine the volume of gas delivered by centrifugal exhausters are more easily, and therefore more frequently made, than the corresponding tests of rotary exhausters, because the discharge of the latter is pulsating. Nozzles or orifices cannot be used to measure pulsating flow unless the pulsations are eliminated. But the main reason why these tests are so seldom performed on rotary exhausters is that every rotary exhauster is a meter of the displacement type, so that the speed of the exhauster is a measure of the quantity of gas delivered. A definite quantity of gas is imprisoned during each cycle and delivered positively except for the leakage or slip which is constant regardless of speed, depending only upon the inlet and outlet pressures, and upon the density of the fluid being pumped.

Figure 1 is usually assumed to be correct. From it we see that at very low speeds more fluid slips back than the exhauster delivers, provided that the discharge pressure is maintained constant from a source outside the exhauster. In each rotary exhauster there is speed, commonly referred to as the "slip," at which the leakage accounts for all of the gas handled by the exhauster. Above this speed the exhauster delivers its full displacement to the discharge system. The probable delivery, therefore, is found by multiplying the difference between the "slip" speed and the actual speed by the displacement of the exhauster per revolution. Evidently the volumetric efficiency increases with the speed. When the speed of the exhauster is 10 times the "slip" speed, the volumetric efficiency is 90 per cent.

Some operators of rotary blowers and exhausters think that probably other factors enter into the rate of delivery. The suspicion is rather general that pressure drop, due to friction in the intake pipe, reduces the delivery and counteracts the increase in efficiency due to the higher ratio of $\frac{\text{actual speed}}{\text{slip speed.}}$

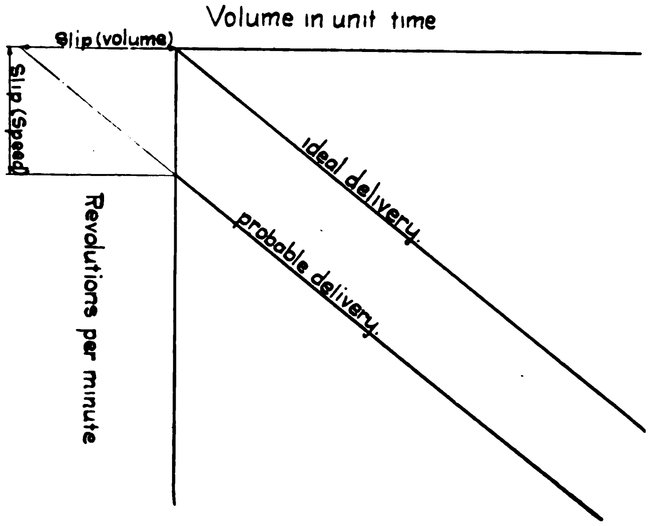

Fig. 1—Curve showing that at low speeds more fluid slips back than the exhauster delivers, provided that the discharge pressure is maintained constant from a source outside the exhauster.

In order to clear up these points, Prof. W. Trinks undertook a test at the Carnegie Institute of Technology on the delivery of a Roots rotary blower, furnished by the P. H. & F. M. Roots Co., of Connersville, Ind. The test arrangement is clearly shown in Fig. 2. The air enters the right hand tank through standard nozzles. This tank is closed at

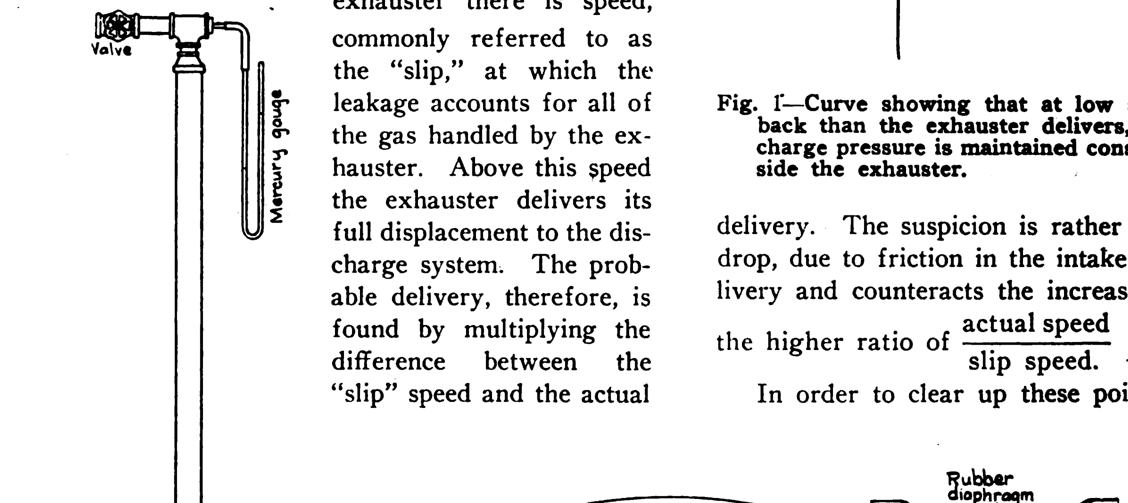

Fig. 2—Showing arrangement of test apparatus on the rotary blower.

the top by a very thin rubber diaphragm, the mass of which is so thin that it vibrates with the pulsations of the air in the intake pipe and converts them into practically steady flow through the nozzles. When the blower is in operation the oil in the draft gauge near the blower vibrates with the pulsations in the air column, while the oil in the draft gauge at the measuring tank is motionless. The water seal at the extreme right of Fig. 2 saves the rather expensive rubber diaphragm in case the blower is started with all the nozzles closed. The intermediate tank between the measuring tank and the blower is not absolutely necessary in this test, because the vacuum produced is not greater than the rubber diaphragm will allow.

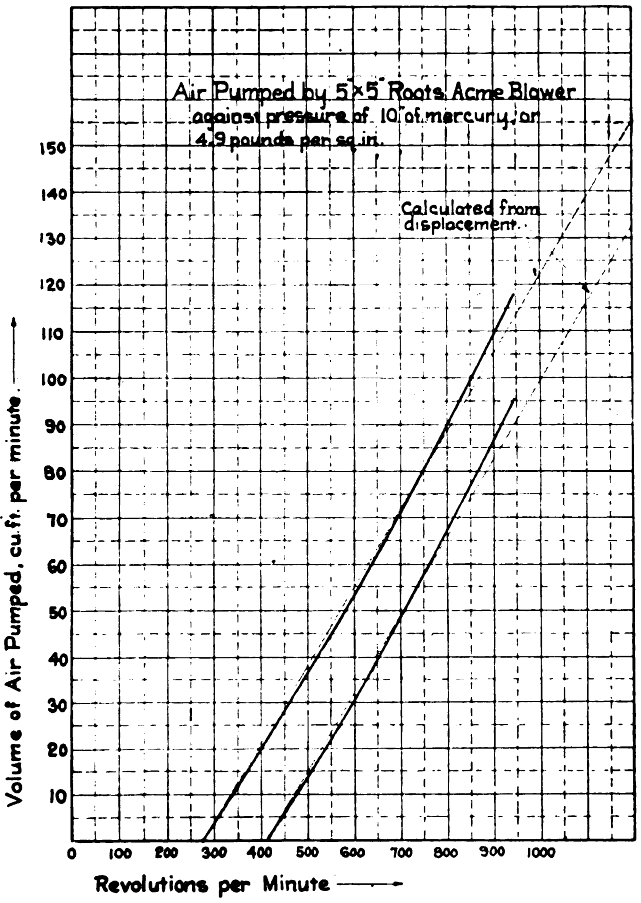

Fig. 3—Relation between quantity of air delivered and speed of blower.

The results of this test are shown in Fig. 3, which shows the relation between the quantity of air delivered and the speed of the blower. The test of the blower as originally built produced the left hand curve. The results were so surprising that the tests were repeated with a larger slip speed. In order to get a larger slip the headplates were removed from the blower and more red lead was put into the joint. The right hand curve was obtained from this test. It will be seen that the character of both curves is exactly the same. The length and shape of the inlet pipe were varied and the location of the pressure gauge on the outlet was changed; but none of these changes had any appreciable influence on the shape of the characteristic curves.

It is interesting to note that the actual delivery falls below the probable delivery at lower speeds and rises above it at higher speeds. Vibrations of the air column undoubtedly explain this peculiarity. At low speeds the whole column is accelerated and retarded, but as the speed increases the inertia of the column causes vibrations of sound-wave character to appear. At certain speeds, the phase of these vibrations corresponds with the opening of the blower to the suction and an extra quantity of air is shoved into the blower, thus increasing delivery. This case is parallel to that of blowing engines with air intake pipes and automatic inlet valves where the delivery is likewise increased by the inertia of the air in the intake pipe.

It is an interesting fact that the vibrations have a phase-lag against the impressed vibration of the blower. This may explain why attempts to furnish an engine torque of the blower have not been successful.

It should be noted that in these tests the discharge pressure was five pounds per square inch. At lower pressures the slip speed is much less.

Vibrations occur not only in the intake, but also in the discharge pipe. It has been thought that perhaps at high speeds these vibrations might become destructive. It is true that vibrations increase with the speed, but only up to the point where they become sound-waves. Above this speed the pitch of the sound, i. e., frequency of vibration, increases; but the amplitude, i. e., loudness, remains constant. The maximum vibration depends upon the ratio of outlet pipe size to fluctuation of displacement. The smaller the outlet pipe for a given blower, the worse the vibration becomes. With the average size of outlet pipe the vibration to either side from mean does not exceed 10 per cent of the absolute average outlet pressure. In unusually long pipes, however, resonance might increase this somewhat.

EDITOR'S NOTE—In the October, 1917, issue of THE BLAST FURNACE AND STEEL PLANT, W. Trinks discussed by-product coke oven pressure regulation. Some of the statements may be of interest here. We quote as follows:

"So important is this consideration (constant pressure) that the engineers of by-product coke ovens try to keep the pressure at the oven constant within one or two millimeters of water pressure. If we remember that the pressure of the atmosphere is about 10,000 mm of water, then we realize how close this pressure regulation is. It means keeping the pressure constant within 1/100 to 1/50 of 1 per cent. This regulation is so close that it is distributed over two governing systems. The governors on the gas exhausters keep the pressure constant within 10 to 20 mm of water, whereas the finer regulation is entrusted to another governor which is known as a "battery governor" or "coke over pressure regulator."

The Elements of Roll Pass Design

Analysis of a "Bending-Up" Pass in the Rolling of Channels. Migration of the Material in the Counterflange Method of Rolling Channels — Sidework and Proper Filling of Pass.

By W. TRINKS.

In the June issue of THE BLAST FURNACE AND STEEL PLANT several different methods for rolling channels were given, with the conclusion that sound sections could be produced by any one of the three methods. For want of a better name, they had been termed the "bending-up" method, the "counterflange" method, and the "combination" method.

In the present installment, one pass from each process of rolling will be analyzed, by means of the method employed right along in this series, namely, that of making sections through rolls and bar, at right angles to the latter, ahead of the center of the roll.

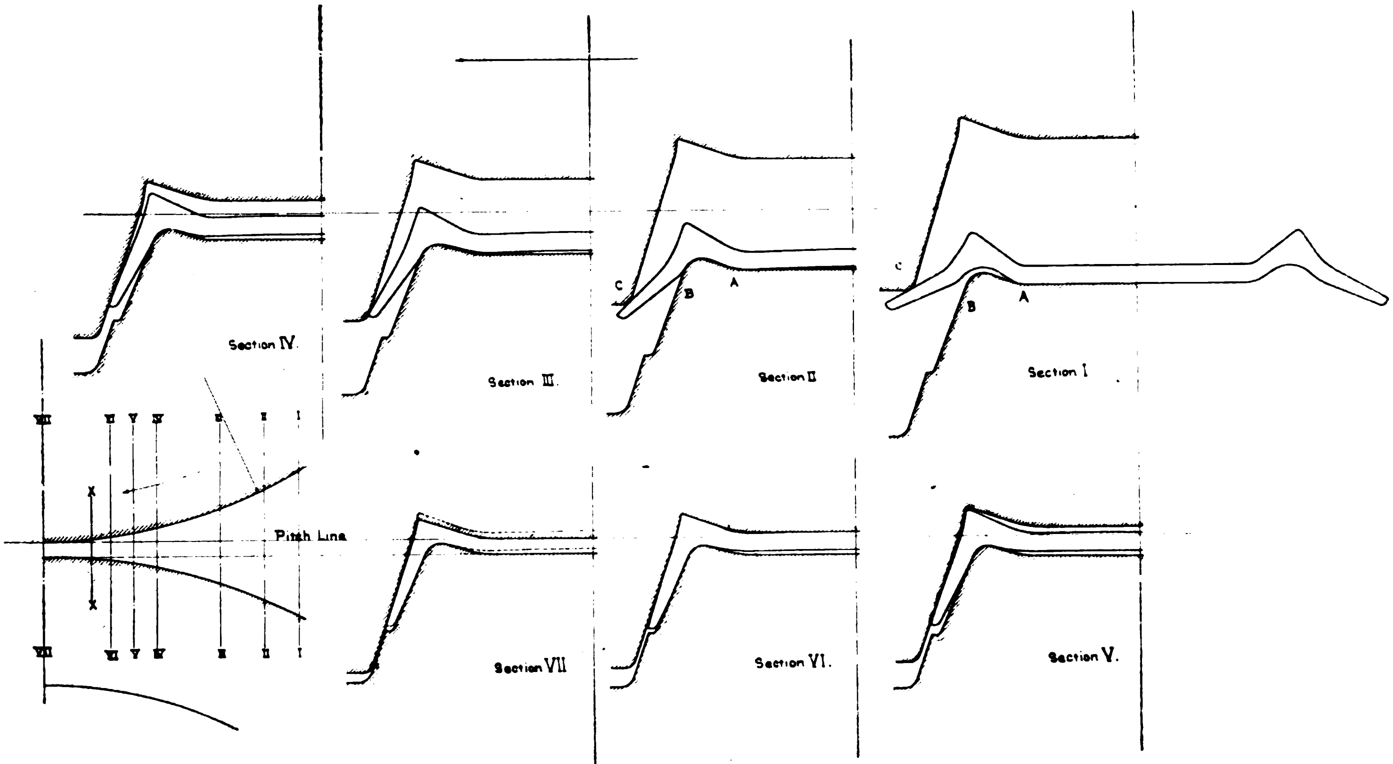

Fig. 1—Analysis of bending-up method of rolling channels.

From each process of rolling that pass was selected which most clearly shows the peculiarities of each of the three processes.

Fig. 1 illustrates that pass of the bending-up method in which the greatest bending occurs. When entering the pass, the bar touches the rolls as indicated in section I. It will be shown later on that the bar is in contact with the rolls at section I at entrance only, and that no contact takes place in that section for the rest of the bar. The corner C of the upper roll gradually and steadily bends the flange around the rounded projection AB of the lower roll. The amount of bending is so great in the short distance I-III that the bent flange at section III reacts and bends the flange in sections I and II more than the position of the upper roll would indicate. This backwardly extending influence of the quick bend stops contact between bar and roll at point C in these two sections. Likewise, the bar has been raised by the bottom roll in section III so that it is lifted away from the lower roll in sections I and II. It is quite evident, then, that there is no contact between bar and roll in these sections, as above indicated.

The amount of bending in this one pass is very great, so great that cracking of the steel would occur, if all, or almost all, of the bending deformation were concentrated at one spot. The latter possibility is prevented by the gentle curve of the corner AB of the bottom roll. If deformation tried to crowd into one spot, the bar would make contact with the bottom roll and would be bent as indicated in sections I and II; that is to say, with the point of greatest bending gradually progressing from the root of the flange towards its top. Up to and including section V, bending of the flanges and a slight bending of the web (caused by transmission of the bending moment) are the only deformations taking place in the bar. At section VI compression begins at the corner. At the section marked XX compression of the web begins. It ends, of course, at section VII. Compression of the flange begins slightly ahead of section VI. On account of the inclination of the flange, compression of the latter must begin ahead of that of the web, if the same draft is to be obtained in both members.

The reduction in the web is about 15 per cent, while that of the flange is only about 11 per cent. The flange would, therefore, be shortened, and would not fill, if it were not for the excess material in the corner between flange and web, which excess material is shoved down into the flange so that the latter just fills.

No work is put on the edge of the flange in this pass. The necessary side work was obtained in the passes ahead of the one just analyzed. See the June issue.

Fig. 2 is a graphical analysis of a pass from the counterflange method of rolling channels. It will be remembered that this method consists in rolling a beam blank, similar to that used for an I-beam, and in then squeezing the material of the counterflange into the other, final flange. The counterflange lies alternately in the live part and in the dead part of the pass, if the channel is rolled in a three-high mill. In order to free themselves from the rolls, the flanges must be inclined, which means that they must be bent "in and out" alternately. This fact shows up very well in sections I and II of Fig. 2, where the main flange strikes at the bottom outer edge. The action in these sections is that of bending the flanges and of allowing the main flange to slide into place.

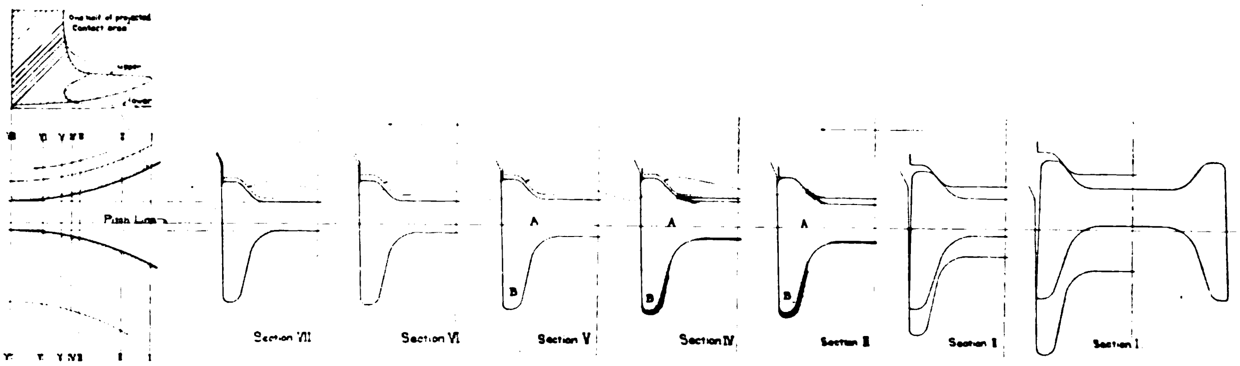

Fig. 2—Analysis of counterflange method.

From section III, Fig. 2, on, the flanges are compressed all the way over to section VII, while compression of the web takes place only between the limits of sections V to VII. This difference in duration of compression introduces a peculiar movement of the material. From sections III to V the flange only is compressed. The compression cannot altogether go into elongation; because any elongation of the flanges has to take the web along. Hence there must be some spreading. Material at the point marked A can escape into the web and assist in its elongation. Material at point B cannot migrate into the web, so that space for its spreading must be provided. Note that the pass into which the flange enters is slightly wider at the bottom, allowing room for the spreading. This condition holds to section V only. From there on the reduction (in per cent of initial section at V) is much greater in the web than it is in the flanges. The web tends to elongate more than the flanges and pulls the latter along. The material at A, which first migrated from the flange into the web, now returns to the flange.

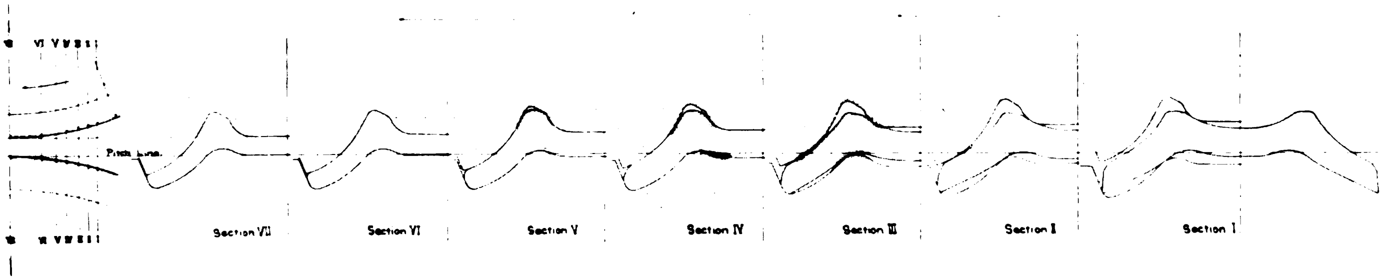

Fig. 3—Analysis of combination method of rolling channels.

A rough calculation of what goes on from sections V to VII may be of interest. The elongation of the web alone (with spreading prevented) would be 32 per cent, while the elongation of the flange alone would be 8 per cent. But the ratio of the area of the web to that of the flanges is as 4½ to 7. Hence, the resulting elongation is $\frac{32 \times 4.5 + 8 \times 7}{11.5} = 17.4$ per cent, unless the shape of the projected contact area gives one of the two factors an undue preponderance

But if $\frac{17.4}{32}$ of the ideal elongation of the web goes into real elongation, the other $\frac{14.6}{32}$ must go into feeding the flanges. The displaced area of the web is 2 square inches, so that $\frac{14.6 \times 1 \times 2}{32 \times 2}$, or .455 square inch, goes into each flange to make up the deficiency. This calls for a spreading of about ⅓-inch into each flange. The shape of the projected contact area of the web (5½ × 2¼) is that of a rectangle of ratio of sides of 2.4. Hence $\frac{2.4}{3.4}$ of the displaced area would go into elongation, and $\frac{1}{3.4}$ of that area would go into spreading, if there were no lateral restraint. Hence $\frac{1}{2} \times \frac{2}{3.4} = .3$ square inch would naturally go into each flange. The difference between .45 square inch and .3 square inch is not sufficiently great to cause any "pulling down" of the flanges, but they may not quite fill in section VII.

Considerations of the same character do not enter into Fig. 3, which is an analysis of a pass from the combination or halfway method. Like the pass of Fig. 2, that of Fig. 3 is far enough away from the finishing pass to make side work on the edges both possible and desirable.

Between sections I and II there occurs only bending of the section, coupled with local deformation at the tip of the flange; the latter is very similar to that discussed in connection with the rolling of sheet bars. The same is more or less true between sections II and III; that is to say, no elongation of any account occurs. From Section IV on, compression and elongation begin. However, there is no compression in the corner between flange and web until somewhere between Sections V and VI. Just why the designer of the series of passes from which this example is taken provided less compression in the corner is not definitely known to the author. The following is, however, a plausible explanation: In the pass under discussion, the reduction in the flanges (38 per cent) is slightly greater than the reduction in the web (35 per cent). The excess compression in the flanges causes in them a tendency to spread. But the spreading is prevented, which means that side work is done. In the passes which follow, the same ratio of reduction cannot be maintained; first, because the flanges would become too thin, and second, because the bent-up position of the flanges does not allow of heavy reductions. Therefore the extra material left in the corners in the present pass "comes in handy" in the finishing pass and in those immediately ahead of that latter pass, as explained in connection with Fig. 1.

In Fig. 3, the pass is filled nicely. No fin is produced, in spite of the side work. This is largely due to the slope and chamfer at the edge of the flange (See section I, Fig. 3.)

The method of rolling exemplified by Fig. 3 has the great advantage that side work is done on or against inclined surfaces which can be dressed, after wear has occurred. In the method of rolling, exemplified by Fig. 1 (and by Fig. 4 of the June issue) that is not the case.

Phosphorus in Soft Open Hearth Steel

Investigation of Effects of Phosphorus in Soft Acid and Basic Open Hearth Steels Show That Hardness Increases With Increased Phosphorus, but Steels Are Not Made Brittle or Cold Short.

By J. S. UNGER

PART II.

Threading Tests.

To determine what differences might exist in the finish and power required in machining, threading tests were made in duplicate on bars 1.016 inch in diameter, in the rolled condition and after heating to 900 deg. C. and quenching in cold water. A die cutting 14 threads per inch was equipped with a lever to which a dynamo-meter was attached, to measure the pull in pounds, while cutting the threads. The results are shown in Table X.

Table X—Results of Threading Tests.

Kind of steel	Phos. content	Power Required As rolled	Power Required Quenched from 900 deg. C., in cold water
Acid O. H..........	.032	22.0 lbs.	37.0 lbs.
Acid O. H..........	.058	23.7 lbs.	35.5 lbs.
Acid O. H..........	.085	25.3 lbs.	38.0 lbs.
Acid O. H..........	.115	23.5 lbs.	35.5 lbs.
Basic O. H..........	.008	23.0 lbs.	41.5 lbs.
Basic O. H..........	.030	22.7 lbs.	35.5 lbs.
Basic O. H..........	.052	23.3 lbs.	36.0 lbs.
Basic O. H..........	.080	26.0 lbs.	45.5 lbs.
Basic O. H..........	.110	20.7 lbs.	39.5 lbs.

Cold Drawn Shafting.

Duplicate rolled rounds 30 feet long and 1.016-inch diameter were pickled at one time in the same acid

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Second installment of paper read before May meeting of American Iron and Steel Institute.

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solution and then drawn into rounds .933-inch in diameter. The noticeable thing was the greater action of the pickling acid as the phosphorus increased. This is shown in the gradually decreasing diameters and the condition of the surface of the bars before drawing. This was pronounced enough to enable one to tell the phosphorus content by the diameter of the bar after pickling. After drawing, straightening and inspection, every experimental bar was commercially perfect and was applied on current orders. The results are given in Table XI.

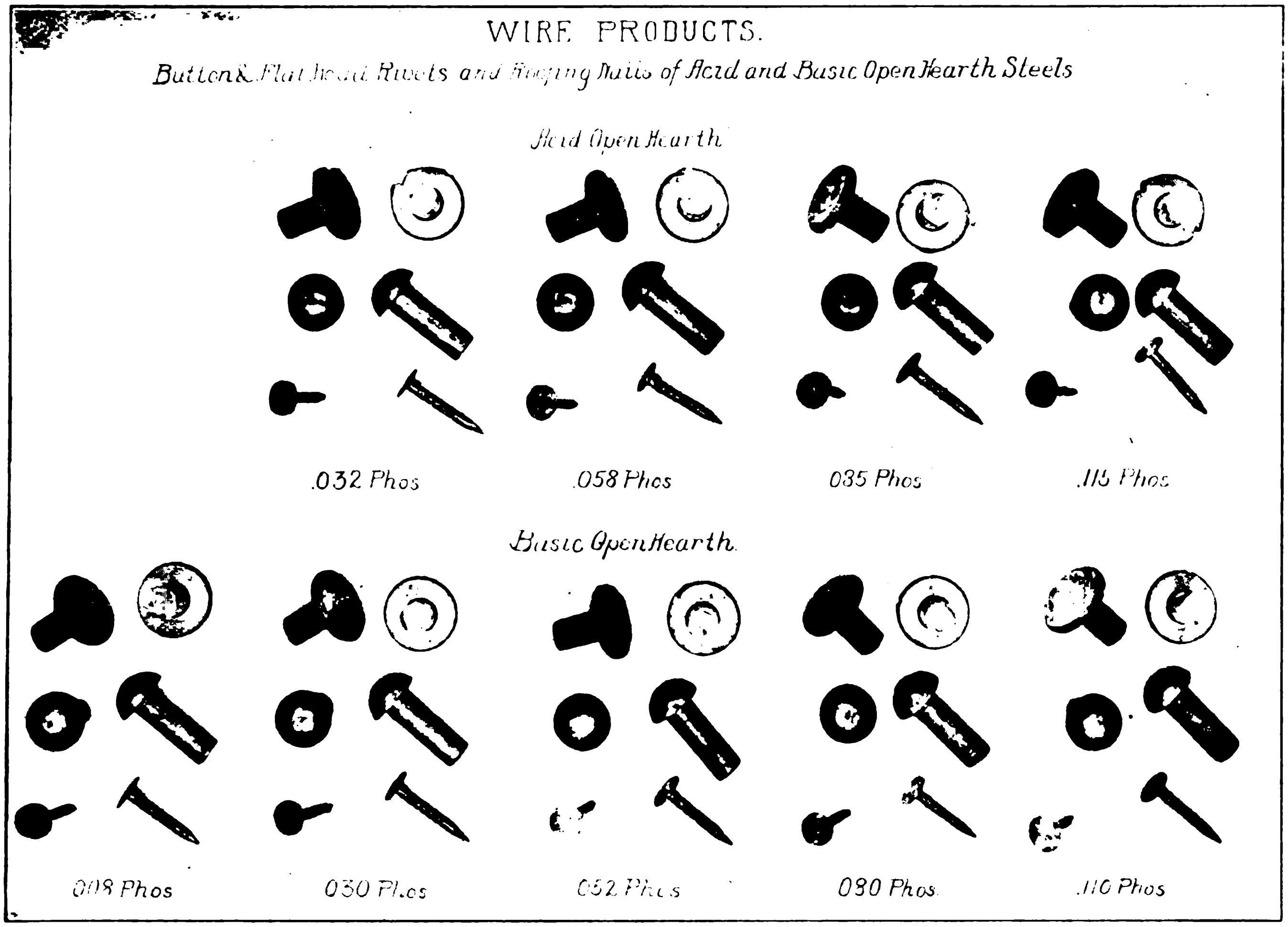

Fig. 4.

Table XI—Results of Cold Drawing Experiment.

Kind of steel	Phos. content	Diam. of bar before pickling	Diam. of bar after pickling	Condition of surface after pickling	Diam. of bar after drawing
Acid O. H..	.032	1.016"	1.011"	Smooth	.933"
Acid O. H..	.058	1.016"	1.007"	Smooth	.933"
Acid O. H..	.085	1.016"	1.006"	Rough	.933"
Acid O. H..	.115	1.016"	1.003"	Rough-Seamy	.933"
Basic O. H..	.008	1.016"	1.013"	Smooth	.933"
Basic O. H..	.030	1.016"	1.011"	Smooth	.933"
Basic O. H..	.052	1.016"	1.009"	Moderately smooth	.933"
Basic O. H..	.080	1.016"	1.006"	Rough	.933"
Basic O. H..	.110	1.016"	1.002"	Rough-Seamy	.933"

Wire Products.

Three 4 by 4 inch billets of each grade were rolled into wire rod, then drawn into wire of various sizes and used to make 1-inch ten-jaw barbed roofing nails with 7/16-inch heads; button head rivets, length 1-inch, diameter of shank ⅜-inch, diameter of head ⅝-inch; flat-head rivets, length ⅝-inch, diameter of shank ⅜-inch, diameter of head ⅞-inch, and thickness of head .145-inch. In drawing the wire, it was found that the steel was harder to draw and more breaks occurred in drawing as the phosphorus content increased.

In making the roofing nails, it was necessary to regrind the hammers more frequently than on regular dead-soft open hearth stock, as the wire was harder to head up. Outside of this trouble, all grades were made up into perfect roofing nails. In heading the button-head rivets the results were erratic, due probably to some small difference in the operation. It can be said in a general way only, that the harder the steel, the greater the difficulty in heading the rivet. The flat-head rivet was a very severe upsetting operation. It may be called a dynamic upsetting test, and unless the steel is very soft, it will not produce a head free from cracks at the edges.

The tests on the wire rod and the mill practice on

Table XII—Tests and Mill Practice on Wire Products.

Kind of steel.	Phos. content.	Wire rod .406" diam. ult. str., lbs. sq. in.	Elongation wire rod per cent in 10".	Wire .365" diam. ult. str. lbs. sq. in.	Elongation wire per cent in 10".	Button-head rivets per ct. good heads	Flat-head rivets per cent good heads.
Acid O. H......	.032	51,500	21.2	82,00	Broke in Jaws	41.2	6.2
Acid O. H......	.058	56,500	24.2	83,500	3.8	90.0	....
Acid O. H......	.085	56,900	23.8	81,000	3.5	14.8	....
Acid O. H......	.115	63,500	23.7	89,900	Broke in Jaws	15.4	....
Basic O. H......	.008	48,800	26.7	75,600	Broke in Jaws	100.0	88.6
Basic O. H......	.030	50,900	25.0	78,600	4.8	100.0	21.8
Basic O. H......	.052	54,300	23.8	80,000	5.0	85.7	2.0
Basic O. H......	.080	54,700	25.0	83,200	4.7	40.7	3.7
Basic O. H......	.110	58,700	27.2	85,500	4.9	96.6	....
Reg. dead soft O. H. .06C......	....	39,250	27.5	71,000	6.5	100.0	13.9

the button-head and flat-head rivets are given in Table XII and in Fig. 4. For purposes of comparison, a dead-soft basic open hearth regular steel of about .06 per cent carbon was carried along with the experimental steels.

Student Lamp Cups and Automobile Hub Caps.

Steel of each grade was made into cold rolled strip steel and then stamped into cups for student lamps and automobile hub caps.

No difficulty was experienced with any of this steel, all of it being made into perfect lamp cups or automobile hub cups, and no differences could be observed in the finished articles, regardless of phosphorus content.

Steel Barrels.

Slabs of each grade of steel were rolled into sheets .130-inch thick, sheared into discs 57½ inches in diameter and fabricated into 55 gallon gasoline or oil barrels.

The process of manufacture into barrels consisted of four straight drawing operations with intermediate annealing and pickling; followed by three final operations, consisting of bilging, forming the chine and curling the edge.

A total of 215 discs were used, of which eight had to be scrapped, six of which were due to defective sheets, one to mechanical operation and one due to crack developing during drawing; making a total of 207 barrels, which were tested with air for leaks and accepted. Fig. 5 shows a sample disc and one barrel of each grade of steel, and Table XIII gives the number of each kind made and the practice on the same.

Automobile Running Board Shields.

Sheet bars of each grade of steel were rolled into sheets 18⅛ by 65 inches by 22 gage (.03125 inch) and the sheets made into running board shields.

No trouble was experienced in the manufacture of the shields from any grade of steel, and the total number of 285 pieces, or approximately 32 pieces of each grade, were made into finished shields and used with the regular material in the manufacture of cars.

Table XIII—Results with Steel Barrels.

Kind of steel	Phos. content	No. pieces tested	No. good barrels	Per cent good barrels
Acid O. H........	.032	24	23	96
Acid O. H........	.058	24	24	100
Acid O. H........	.085	24	24	100
Acid O. H........	.115	24	23	96
Basic O. H........	.008	24	22	92
Basic O. H........	.030	23	23	100
Basic O. H........	.052	24	22	92
Basic O. H........	.080	24	24	100
Basic O. H........	.110	24	22	92

In fabricating these shields, most of the trouble is experienced in turning over the edge along the curved portion at the top of the shield, but none of the experimental steel cracked.

Automobile Cowls.

Sheets 35 by 84 inches by 20 gage (.0375 inch) were used for fabricating into automobile cowls or shrouds, 17 pieces of each grade of steel being used, or a total of 153 sheets, all of which were made into cowls and used in the manufacture of cars in accordance with the usual shop practice; with the exception of one cowl of low phosphorus basic open hearth steel, which had to be scrapped on account of the sheet being defective.

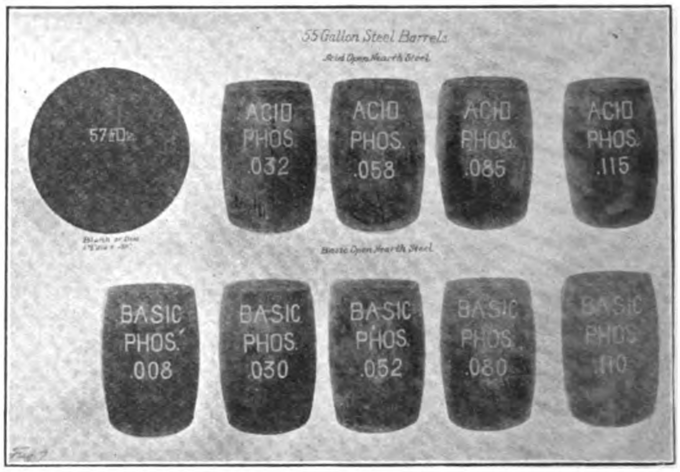

Fig. 5.

Automobile Raditator Casings.

Radiator casings were made from sheets 32 by 35 inches by 20 gage (.0375 inch) of each grade of steel, a total of 293 sheets, or approximately 32 sheets of each grade being used.

The results obtained were erratic. The draw in this operation is made very quickly and most of this steel seemed to be too stiff for the purpose, although the softest steel of the lot, or the .008 phosphorus basic, gave much worse results than a number of the other grades. Fig. 6 shows a characteristic radiator casing of each grade of steel, and Table XIV shows

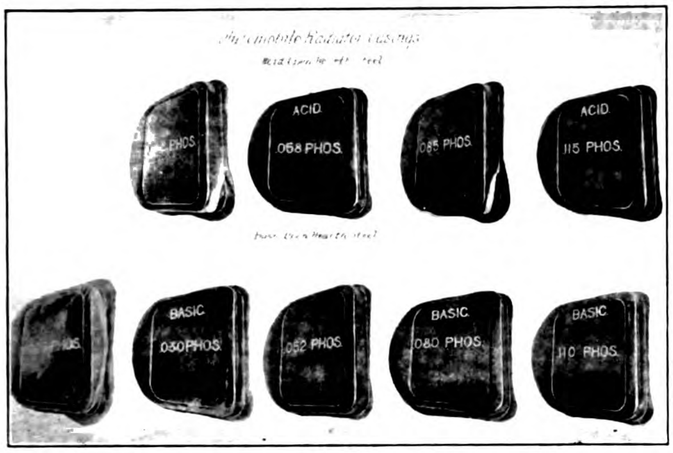

Fig. 6.

the number of pieces of each grade tested, the number of casings used in the manufacture of automobiles and the percentage or shop practice obtained.

Table XIV—Results with Automobile Radiator Casings.

Kind of steel	Phos. content	No. pieces tested	No. casings used	No. casings scrapped	Percentage casings used
Acid O. H....	.032	35	5	30	14
Acid O. H....	.058	32	20	12	63
Acid O. H....	.085	35	1	34	3
Acid O. H....	.115	35	..	35	..
Basic O. H....	.008	29	5	24	16
Basic O. H....	.030	32	20	12	63
Basic O. H....	.052	31	27	4	87
Basic O. H....	.080	32	16	16	50
Basic O. H....	.110	32	3	29	9

Automobile Corner Panels.

Two sizes of corner panels were made of each grade of steel. For the large size, sheets 35 by 84 inches by 20 gage (.0375 inch) were used; and for the smaller size, sheets 34 by 48 inches by 20 gage.

This operation is very severe, and while the results were to some extent erratic, the stiffer or harder steels as a whole gave poorer results than the steels with lower tensile strength; or, in other words, the higher phosphorus steels were too hard for the purpose.

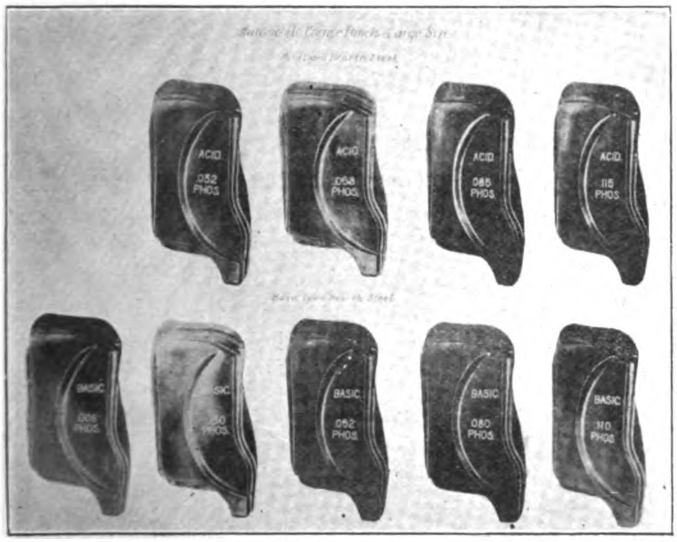

Fig. 7.

Fig. 7 shows characteristic corner panels of each grade.

Table XV shows the number of sheets of each grade tested for both the large and small corner panels, the number of panels of each kind used in the manufacture of cars and the percentage of panels used, or the shop practice.

Table XV—Results with Automobile Corner Panels.

	Large Corner Panels				Small Corner Panels		
Kind of steel	Phos. content	No. pieces tested	Panels used in autos	Pr. ct. panels used	No. pieces tested	Panels used in autos	Pr. ct. p'nls used
Acid O. H..	.032	17	8	47	35	20	57
Acid O. H..	.058	18	5	28	35	28	80
Acid O. H..	.085	16	..	...	35	19	54
Acid O. H..	.115	18	1	6	35	6	17
Basic O. H..	.008	17	17	100	32	32	100
Basic O. H..	.030	18	18	100	34	33	97
Basic O. H..	.052	18	15	83	31	30	97
Basic O. H..	.080	18	8	44	32	22	69
Basic O. H..	.110	18	15	83	32	25	78

Cream Separator Bowls.

Sheets of each grade, 18 gage (.050 inch), were made into cream separator bowls.

The process of manufacture consisted of four drawing operations, followed by an annealing and a fifth drawing operation; after which the bowl was hydraulically expanded to shape, edges curled, opening punched for outlet drain, bowls cleaned, pickled and then tinned. The finished bowl is 8 inches deep, 14⅛ inches in diameter at the belly and 12⅜ inches in diameter at the neck.

The first drawing operation is particularly severe, owing to the size and shape of depression for the outlet drain. Unless the steel is very soft and ductile it will tear at the deep end of this depression and cause the rejection of the bowl. The higher phosphorus steels were too hard and stiff for this operation and a number of them failed, particularly the .085 and .115 per cent phosphorus acid steels.

Table XVI—Results with Cream Separator Bowls.

Kind of steel	Phos. content	No. pieces tested	Failures on drawing operation	Failures on expanding operation	No. bowls used	Percentage bowls used
Acid O. H...	.032	35	8	0	27	77
Acid O. H...	.058	35	14	0	21	60
Acid O. H...	.085	35	35	..	0	0
Acid O. H...	.115	35	29	3	3	9
Basic O. H...	.008	35	3	0	32	91
Basic O. H...	.030	35	3	0	32	91
Basic O. H...	.052	35	3	0	32	91
Basic O. H...	.080	35	10	2	23	66
Basic O. H...	.110	35	8	3	25	69

A total of 315 sheets were used, or 35 of each grade, and a total of 194 perfect bowls were made and used in the manufacture of cream separators. Table XVI shows the number of each grade tested, failures on drawing and expanding operations and the number of perfect bowls.

Conclusion.

The results of this investigation speak for them-

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selves. None of the steels showed brittleness under cold working, due to the phosphorus. An examination of the results of the various mechanical tests, cold bending of the rivets under a hammer, the severe upsetting in making large headed nails or rivets, or the fabrication of barrels, automobile parts and cream separator bowls indicate nothing more than an increased hardness due to increase in phosphorus. This condition remains the same regardless of whether the force was applied slowly or statically, or if applied by shock or blow.

The results show that in soft steels an increase in phosphorus of .01 per cent is equivalent to an increase in tensile strength of about 850 pounds per square inch, which is practically the same as would be obtained by increasing the carbon .01 per cent. Hence, higher phosphorus, soft or low carbon steels can be used for various purposes, provided the carbon content is decreased sufficiently to compensate for the increased hardness due to the phosphorus.

In conclusion, I wish to express my thanks to the various steel works and other manufacturers who assisted in carrying out this investigation.

By-Product Coke Oven Pressure Regulation

The First of a Series of Articles Dealing With the Subject of By-Product Coke Oven Pressure Regulation — In the Frst Installment the General Theory of Regulation Is Discussed.

By CHARLES H. SMOOT,
Rateau Battu Smoot Company.

The importance of the gas pressure regulation in a by-product coke oven retort is much greater than would appear from offhand consideration.

The retort in which the coal is reduced to coke is a structure having very large surfaces and the materials employed in its construction are such that it cannot be made airtight. At best there are always a number of small cracks in the walls through which air and gases may enter and escape.

Within the retort the coal in process of coking is at a high temperature and ready to ignite with any oxygen which may enter. Also any of the gaseous products within the retort which may escape to atmosphere are waste. Thus leakage of air into, or gas out of the retort, is a direct loss of product. The entry of air is the more objectionable for other reasons than loss of gas.

While any one crack in the retort wall may appear small, the aggregate of all these leakage openings is large because of the great area presented by the total retort walls in a battery of retorts.

It is obviously not sufficient to regulate the pressure within the retort so that the escape of gas is not apparent. When the escape of gas is such as to strike the attention of the casual observer the losses are enormous. A small loss at each point included in the large volume of space occupied by a battery of coke ovens will aggregate a very large amount of wasted product, even though none of the individual losses are sufficiently large to attract special attention.

The best care available in maintaining the retorts is incapable of keeping them airtight. In order to reduce the loss of product and avoid leakage the only remedy is in pressure regulation and the pressure within the retort should be regulated so close to the pressure outside of the retort that there is no force or pressure difference to cause the escape of gas from the interior to the exterior or entry of air from the exterior to the interior.

In other words, the pressure difference must be so small that the flow through the aggregate net leakage openings is reduced to the minimum possible amount.

When it is realized that the total leakage area presented by a battery of retorts is equivalent to a wide open hole of many square inches, it will be readily grasped that a large amount of waste will occur for even the most minute pressure difference across this opening. In consequence of this it is essential that the pressure within the retort be regulated—not in pounds or inches of water pressure—but to millimeters and preferably to fractions of a millimeter of water pressure.

The volume of air which will enter the retort battery through openings, whose aggregate area is equivalent to 1 square foot, is shown in Fig. 1.

From the above considerations, without regard to the other ones which are present in the process of making coke, it is obvious from the point of view of economical operation only that a high degree of accuracy in pressure regulation is essential. This has been well recognized in the past and many attempts have been made to attain accurate regulation.

It is not alone necessary that the average pressure over several minutes be closely regulated, but the actual pressure second by second, must be regulated. A pressure which is varying two or three millimeters from the average value will cause excessive waste of gas and surplus pressure and waste from combustion due to entering air on deficient pressure. Such a condition, however, may not be apparent on slow-moving pressure-recording gages, which because of their slow motion and inertia of moving parts, show only the average pressure for some little interval and thus do not indicate the oscillations in pressure either side of the value registered. The net result of the quick oscillations represent a considerable waste of product.

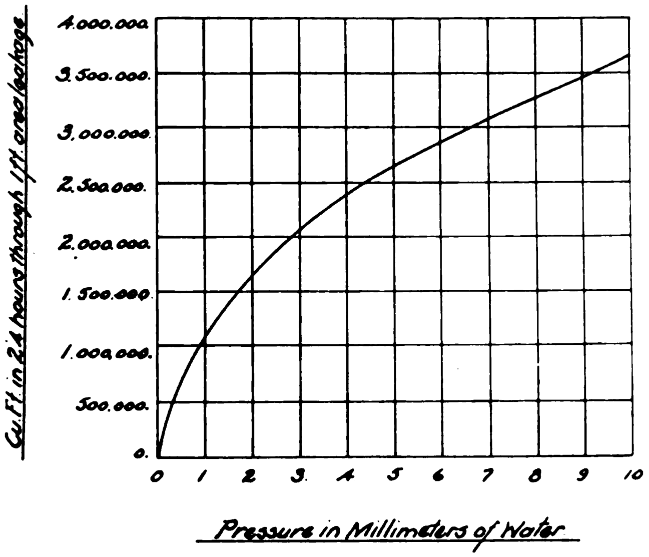


Fig. 1—Volume of air which will enter the retort battery through openings whose aggregate area is equivalent to 1 square foot.

With inaccurate slow-acting regulators in use, it is customary to keep the pressure in the retorts at several millimeters, or enough above atmosphere to prevent air entry on the low pressure swings. The average pressure, therefore, is high by one-half of the pressure variation. If the variation in pressure were reduced by means of a more accurate and rapid regulator, the escape of gas would be correspondingly reduced, since the more accurate regulation would permit a reduced average pressure in the retorts. With a regulator dependable at all times to a one-half millimeter variation, a pressure of but one-half millimeter would be needed in the retort to insure against entry of air. Thus economy of operation is directly dependent on accuracy of regulation.

The builders and operators of coke plants have made use of the best equipment available, but owing to the difficulty of operating a regulator with very small pressure differences, it would appear that suitable apparatus for this purpose has not been available and that more accurate equipment should be developed for this purpose.

The difficulty of the problem may be readily grasped in reflecting that a pressure of one millimeter of water exerted on a 10-inch piston gives a net result of but one-ninth of a pound. This force is altogether insufficient to control valves or other means of pressure regulation, and several attempts have been made to increase this pressure through the use of electric motors and other apparatus in order to obtain sufficient force to operate the regulating valves. Unfortunately, most of the methods employed have accomplished sensitiveness of operation at the expense of speed and while the apparatus is made very sensitive to small changes of pressure, it has also been made very slow to respond to such changes and is, therefore, incapable of following the fluctuations in pressure which even a large battery of retorts produce in their collecting mains, or which have their origin in the natural fluctuations of the exhauster regulation.

It would appear obvious at the outset that satisfactory regulation can only be accomplished when the regulator is at once exceedingly sensitive to minute pressures, as well as capable of rapid operation.

A battery of by-product coke ovens is represented in line drawing, Fig. 2, which indicates the battery of ovens with their collecting mains, a regulating valve in the main located close to the battery, piping leading to the coolers and through the exhausters into the by-product apparatus.

In this equipment there are two points of regulation. First, the valve located near the battery of retorts (at A, Fig. 2), made as sensitive as possible and intended to give close regulation to the pressure within the retorts. A regulator suitable for use at this point, under favorable conditions should maintain the pressure within a total variation of one millimeter of water at all times.

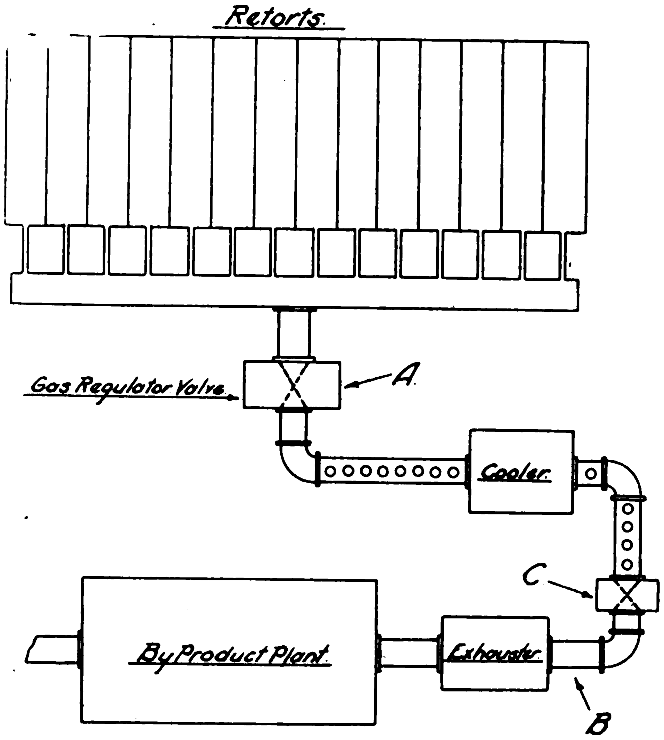


Fig. 2—Battery of by-product coke ovens.

The second point (B, Fig. 2) at which the regulator is installed is in control of the exhauster, which frequently is called on to compress from a suction inlet to a pressure discharge, an aggregate total of 100 inches of water.

It is obviously impossible to regulate this exhauster in such a way that the total variation under changing condition of load will not exceed some 1 or 2 inches of water, corresponding to 1 or 2 per cent variation in total pressure.

To attempt to obtain an exhauster regulation expressed in a few millimeters of water when operating on a total of 2,500 millimeters is obviously impossible, since practical regulation of such apparatus is limited to 1 or 2 per cent variation. It is possible, however, with such an exhauster to obtain a regulation which will place the suction at the exhauster inlet constant within 2 inches of water. This figure includes the maximum swings of short duration.

The lack of close regulation on the exhauster giving variations in suction at the exhauster inlet are transmitted through the gas main back to the gas regulating valve near the retorts—in other words, throughout the piping A to B of Fig. 2.

Located throughout this pipe line are a small number of hand-holes which are opened, giving free access to atmosphere during the tar-cleaning operation. With suction in the piping, air is drawn from the atmosphere into the gas, which it dilutes from the amount of air drawn in.

While the gas temperature is so low that combustion does not result, nevertheless the presence of the air diluting the gas and especially the rich gas is harmful in the process of the by-product reclaimation, and by reducing the richness of the gas brings the point at which the by-product operations cease to be economical earlier in the coke process.

It is obviously desirable to reduce the air dilution as much as possible from other points of view, as when the gas is sold on a certain heat value, the market for the gas ceases when diluted enough with air to reduce the heat value below the salable point, and in some instances necessitates enriching the gas by artificial means in order to maintain its heat value up to the standard.

The only function in the plant regulation dependent on vacuum in this gas line between points A and B in Fig. 2 is that of giving a pressure drop across the gas regulating valve located at point A, which permits the motion of this valve to regulate the pressure at the retorts. If a suction of ¼ to ½ inch of water could always be maintained at the gas regulating valve, this would be amply sufficient for the valve operation under all conditions. Any greater suction in the pipe between A and B increases the amount of air drawn into the gas line, with a resulting loss in the by-product plant and a reduction in money value of the generated gas.

It would, therefore, seem advisable in many instances to take some steps to insure that the suction within this pipe line were never more than necessary for proper regulation at the retort. This condition can be met by the installation of a throttling gas pressure regulator, as shown at C in Fig. 2. This regulation is almost identical to that used near the retort and has a function to maintain a definite suction in the gas line between points C and A.

The exhauster regulator may be independently operated or the exhauster regulation may be taken from the regulator C directly. The presence of the regulating valve at C supplements very greatly the regulation of the exhauster and reduces the variation in suction communicated from the exhauster into the collecting mains. If the exhauster is able to regulate the suction at B to within 2 inches of water, the regulating valve at C could give a suction regulation in the gas main within a few millimeters of water. The combination of the regulator C and the exhauster regulator is equivalent to an exhauster regulator of very much greater accuracy than is possible to obtain without the use of the regulator shown at C.

The function of the pressure regulator located near the retorts is to add to the regulation of the exhauster by varying the throttling between retorts and the exhauster, obtaining a pressure within the retort which is very close to that of the surrounding atmosphere.

This latter valve is, therefore, called on for a double function. First, its opening must vary with the quantity of gas delivered by the battery and retorts, opening and shutting as the volume of gas increases or decreases; and superposed on this regulation is a second variation in opening necessary to compensate for variations in the regulation of the exhauster, which gives a variable drop in pressure through the gas valve. As a result of these two actions, even when the ovens are giving a practically constant flow of gas, the regulating valve must vary its orifice inversely to the variation of the exhauster. Second, with an exhauster maintaining perfectly constant suction the valve must vary correspondingly to variation in volume of gas delivered by the retorts.

To further complicate the regulation of the system, it is incidental to the operation of such a plant to open numerous hand-holes, located in the collecting mains (between A and B, Fig. 2) for the purpose of removing the tar which collects over the interior of the pipe lines. The opening of these hand-holes allows air to enter in quantities proportional to the suction within the main. The entry of this air reduces the suction or pressure drop across the regulating valve, on the one hand, and on the other hand increases the volume to be handled by the exhauster, thus acting on both regulators.

The problems of regulation at the exhauster and at the battery of retorts are quite different in character, but have numerous points of similarity. Furthermore, the regulators have a certain interdependent regulation, since the action of the gas regulator is largely to improve on the action of the exhauster regulator.

There is an additional factor bearing on this problem of regulation dependent on the type of exhauster employed. Where the exhauster is an engine-driven positive displacement type, a change in speed of exhauster must follow all changes in gas volume, even though the pressures remain constant.

With a turbine-driven centrifugal exhauster, the changes in speed by the exhauster need follow changes in pressure only since the exhauster inherently is capable of passing variable volumes with small change in pressure.

In consequence the total changes in speed with the centrifugal exhauster are less than the total changes in speed for the positive exhauster to obtain the same regulation result.

When turbo blowers are used in parallel for exhauster duty, special arrangements must be made in their design as well as in the design of their regulators to prevent unequal distribution of load between the several blowers.

It has happened in the past that these conditions have not been taken care of in a proper manner and such turbine exhausters have not been wholly satisfactory, due entirely to lack of proper care in their design and regulation. It is unfortunate that this has been the case, for were they designed to actually meet the conditions of by-product coke oven duty, a most satisfactory exhauster would result.

There is no inherent difficulty in accomplishing parallel operation of these machines, and it is to be hoped that in future installations of turbine-driven centrifugal exhausters that the arrangements for permitting satisfactory parallel operation will be adequate.

The principal difference between the regulation at the retorts and regulation of the exhauster resides in the inertia of the exhauster. A change in position of exhauster regulator makes a change in steam admitted to the engine driving the exhauster, and at some little time interval subsequent to the change in amount of steam there is a change in speed of the exhauster, producing a change in pressure of gas passing through. This time interval is a handicap for the positive displacement machine, but of assistance to the centrifugal type of machine, dependent on their inherent characteristics as outlined above.

On the other hand, motion of the gas regulator at the retorts produces an almost instantaneous change in gas pressure, since the flow of gas is through closed conduits which have little or no storage capacity to correspond to the inertia of rotating mass of the engine or turbo blower.

As a result of this difference in storage capacity, a comparatively slow-acting regulator, which is sensitive, can give satisfactory results on a centrifugal exhauster, an engine-driven exhauster requiring a more rapid regulator, since a change in rotary speed must be accomplished before a change occurs in the volume passed.

At the retorts it is impossible to obtain a regulator too quick in its operation, as there is no equalizing storage or accumulative action; and if the regulator is not rapid the pressures within the retorts cannot be maintained constant except by actual waste, the generated gas being discharged at surplus pressure and air drawn in by a deficient pressure.

The lack of storage capacity within the retort is also a matter of much importance in controlling the regulation of a battery. It is true that there is a large cubic capacity within a battery of retorts, but on the other hand the variation of pressure within this capacity is so minute as to make its cubic capacity of practically no avail as a storage reservoir by the compression and expansion of the gases contained.

The weight of gas contained within a cubic foot of capacity at atmospheric pressure varies approximately but one part in 10,000 for a millimeter of water change in pressure. In consequence, pressure changes of several millimeters within the retort cannot store up and discharge any appreciable amount of gas.

If the regulating valve is incapable of following the variations in volume of gas as rapidly as generated, pressure changes within the retorts will result by an amount sufficient to eventually limit the pressure through the waste of gas or the entry of air.

In default of accurate regulation, a waste of gaseous product in proportion to the departure from constant pressure resulting from the regulator is incurred.

The exhauster regulator does not have to meet this economic condition to anything like the degree incurred by the gas regulator, and if the gas regulator be able to take care of the variations in exhauster regulation and protect the retorts, the losses chargeable to the exhauster for inaccurate regulation will be a moderate increase in its steam consumption, which is of far less money value than the loss incurred at the retorts themselves, and the loss resulting from air entering the main and diluting the gas when too much suction is made by the exhauster.

The leakage area of a retort may be determined by placing a suction on the retort when empty of its charge and measuring through a nozzle the quantity of gas withdrawn. This test has always given surprising results, showing a much larger leakage than anticipated.

It is this same leakage which tends to equalize the pressure in a retort and in part compensate for inaccurate regulation, and results in but moderate changes in pressure within the retort when the regulating valve does not regulate.

On the other hand, the pressure equalization obtained by leakage in this manner is not regulation, but the exact reverse, and is at the expense of gas wasted to atmosphere or burned by entering oxygen.

To obtain close regulation in the by-product coke oven battery would not present any particular difficulty if millimeters of water were multiplied into pounds of pressure and a variation of one pound on a pressure of two pounds would be a very easily solved pressure regulation problem.

Furthermore, the percentage of regulation necessary in a coke oven is large, and when expressed as a percentage, the apparent accuracy of the regulator disappears.

For example, to maintain a pressure of two millimeters of water against atmosphere with a total variation of one millimeter is a 50 per cent variation in the regulator.

It is not in the percentage accuracy, therefore, that the difficulty of this regulation lies. The source of the difficulty in the construction of such a regulator resides rather in the minute force for putting in motion the operating parts of the regulator, due to the small pressure variations to be controlled.

When working within a one-millimeter range of pressure, the lightest possible constructed piston or bell has a very appreciable weight in comparison with the pressure effort of the gas.

A 10-inch bell with the necessary connected parts can hardly be made to weigh less than 1½ to 2 pounds.

One millimeter of water pressure variation on a 10-inch bell delivers an effective impulse to the bell of but one-ninth of a pound.

It is in these figures that the difficulty of the by-product coke oven regulator resides. On the one hand the moving forces are small, and on the other hand the inertia of the mass to be moved is comparatively large. It would appear impossible to obtain a quick-acting regulator which was at once sensitive and stable in its operation when confronted with this difficulty, but by recognizing fully the situation means have been found to construct a regulator which will fulfill all of the conditions necessary.

The disproportion between inertia and moving force may be overcome by limiting to a very small value the travel of the bell, thus reducing the time which it consumes in going from one position to another when acted on by a given impulse.

Among the essential characteristics for a regulator of any kind, and especially a regulator for by-product coke oven plants, is the necessity that the rate of opening and closing the control valve through the action of the regulator be at variable speed.

A given change in gas flow for equalization of pressure requires a corresponding motion of the regulated valve. The time consumed by the valve in going to its new position must be the same as the time during which the gas is increasing and vice versa.

The speed at which the volume of gas changes is a variable quality and is hardly ever twice alike. In consequence a regulator to properly control the flow of gas must have a wide and complete range of possible speeds, from very slow to very fast, in order that its rate of motion may always correspond to the rate in gas change.

It is obvious that a motor-operated valve which has but one speed for change of position, either closing or opening, can correctly follow only one rate in change of gas flow, and is of necessity either too slow or too fast for practically all of the charges of gas flow occurring in practice.

A further essential is that the speed of travel given to the control valve be in proportion to the departure from normal of the regulated pressure. In other words, a small change of a few tenths of a millimeter should give a slow motion to the regulator, and if the regulator be so arranged that its natural rate of travel is fixed and too fast for the slow change of gas, overtravel is unavoidable. On the other hand, if the rate in increase of gas volume be rapid and in excess of the speed of the motor-operated valve, the regulator ceases to be a regulator for a short interval, during which time it is moving as fast as it may go but too slow for the change in gas volume. During this interval the gas pressure may go far from normal, the extent of change being only determined by the rapidity with which the volume of gas is changing in excess of the rapidity with which the control valve is moving.

If a fixed velocity motor-operated valve be geared for rapid motion in order to limit the large pressure changes due to rapid change in gas flow, the overtravel of the regulator is greatly increased when operating on a slow increase in gas flow.

This type of regulator is, therefore, obliged to have a slow speed, found by experience to be a good average, and because of its fixed velocity it is able to regulate correctly but a very small portion of the time.

Another essential for a regulator is its stability, which calls for an element positively preventing overtravel with subsequent oscillations either side of the regulated pressure.

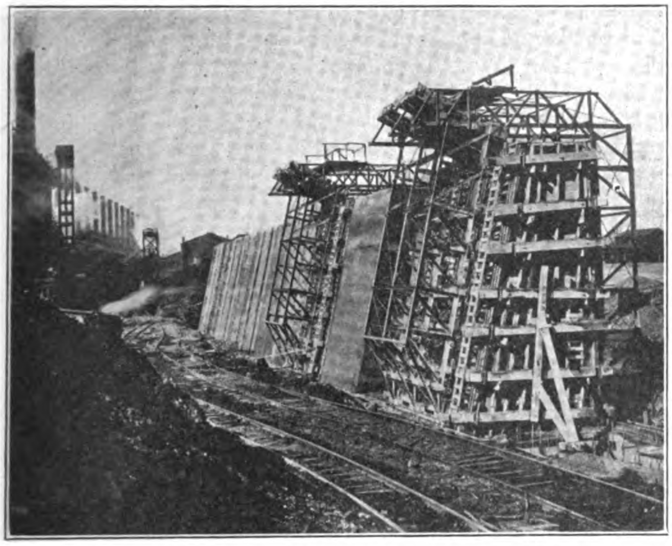
There is no appreciable difference in principle between the gas regulator and an engine governor, as they have the same function to perform and must have the same characteristics to properly function. The behavior of an engine on variable load may readily be imagined if controlled by a slow-operating governor having but one speed change for either opening or closing action.

PRODUCTION TOPICS

CONCRETE CONSTRUCTION FOR STEEL MILL.

The illustration below shows a wall being built for the Brier Hill Steel Company, Youngstown, O. This illustration shows a new type of traveling "Blawform"; the feature being the elimination of the tie rods (spaced about 5 feet apart horizontally and vertically) usually used in this type of form. In place of tie rods the forms are held together by means of jacks pushed against the trusses of the traveler. These trusses are held at the top by means of cross girders and at the very bottom either by struts placed against offsets in the concrete foundation, or by means of large heavy removable steel rods spaced 10 feet apart horizontally. This new type of traveling "Blawform" is placed in from one-third to one-half of the time usually consumed in placing a form of this size.

The most notable advantage of this design is that all stresses can be calculated and solved mathematically; this cannot be done with the old type of form, because the efficiency of the laborers has to be depended upon in placing the small tie rods; if one of them is not placed right the form is apt to give or burst. Another feature of this new type is that the bulkheads, which weigh about 10 tons each, are hinged to the form itself so that they swing open as a door when the strutting and some bolts are removed, resulting in another large saving of labor and time. The form works as indicated in the picture. The first section, furnished with two bulkheads, runs ahead and casts individual blocks. The rear section comes up behind, filling up the alternate gaps between the blocks. This rear section has no bulkheads but overlaps a few inches on the concrete blocks cast in the first section.



A section like this can be moved and set in a forenoon and, if the mixer capacity is large enough, can be filled in the afternoon; in hot weather the section can be removed early in the morning and used again in a similar manner. On some jobs a section of this type could actually be used once every day, even if the wall held dimensions as big as 34 feet in height, 18 feet at bottom, about 10 feet at top and 30 feet long, which is the case in the one shown in the illustration. Generally, however, the work is laid out so that the section is used every other day; that is, with two sections on a job the daily progress consists of a block of the same lengths as the form sections. The sections are made adjustable for different cross-sections of wall. The contractor was Stone & Webster.

SAMPLING IRON.

One of the readers of The Blast Furnace and Steel Plant, I. Peterman, chemist at Holt, Ala., calls attention to an important point in the sampling of iron at the furnace. Sample boys are at times not very careful in taking samples of the cast, which carelessness may result in discrepancies in determining the proper analysis. In order to improve the method of sampling at this particular furnace, samples were taken in a regular manner as follows:

Bed	Si	S
1	1.99	0.024
3	2.17	0.022
5	2.20	.0024
7	2.46	0.024
9	2.57	0.027
11	2.60	0.023
13	2.66	0.022
15	2.85	0.020
17	2.36	0.019
19	1.80	0.023

From the above results it will be seen that the variation is considerable. That is, in case the sample was collected only from the first three or four beds and the last three or four, the percentage of Si would be kept down to an average percentage of 2.08, whereas the average should be around 2.375.

DEFINITION OF COMPRESSED AIR TERMS.

Upon the recommendation of its technical committee, the Compressed Air Society has adopted the following definitions of certain compressed air terms in order to eliminate confusion as to their exact meaning:

Displacement—The displacement of an air compressor is the volume displaced by the net area of the compressor piston.

Capacity—The capacity should be expressed in cubic feet per minute and is the actual amount of air compressed and delivered, expressed in free air at intake temperature and at the pressure of dry air at the suction.

Volumetric efficiency—Volumetric efficiency is the ratio of the capacity to the displacement of the compressor, all as defined above.

Compression efficiency—Compression efficiency is the ratio of the work required to compress isothermally all the air delivered by an air compressor to the work actually done within the compressor cylinder as shown by indicator cards, and may be expressed as the product of the volumetric efficiency, (the intake pressure and the hyperbolic logarithm of the ratio of compression), all divided by the indicated mean effective pressure within the air cylinder or cylinders.

Mechanical efficiency—Mechanical efficiency is the ratio of the air indicated horsepower to the steam indicated horsepower in the case of a steam-driven, and to the brake horsepower in the case of a power-driven machine.

Overall efficiency—Overall efficiency is the product of the compression efficiency and the mechanical efficiency.

The society further recommends that the use of other expressions of efficiency be discontinued.

Some Pointers on By-Product Coke Oven Operations

THE BY-PRODUCT COKE OVEN; ITS PRODUCTS.

By William Hutton Blauvelt.*

In addition to the iron blast furnace, foundry cupolas afford a steady market for coke, and in recent years the domestic market has grown to importance. Before the war, sales of coke for domestic use amounted to over 1,500,000,000 tons per annum, although these sales really rather demonstrated the value of coke as a domestic fuel than showed what were the ultimate possibilities of the trade. Foundry coke is usually made on a somewhat slower coking time than furnace coke, as cupola practice calls for larger and tougher pieces.

The production of domestic coke is now a greatly different industry from what it was in earlier days, when most of the domestic coke was produced in gas works. At that time it was often regarded as something to be got rid of with the least trouble, rather than as a regular and important source of income to the works. Great care is now taken in the sizing and preparation of domestic coke and the complete removal of breeze and dirt. The following table shows approximately the usual sizes produced:

	Size of square through, in	Opening on screen over, in.
Egg coke	3.5	1.5
Nut coke	1.5	1.0
Pea coke	1.0	0.5
Breeze	0.5	

These screens are varied locally to meet market requirements. It would be desirable to have a standard for each domestic size throughout the country, but where the demand for one size is large relative to another, it is natural for the operator to modify his screen openings accordingly.

In American practice, where domestic coke competes mainly with anthracite, a hard structure is generally regarded as desirable. This is contrary to English prace, where familiarity with bituminous coal as a domestic fuel makes quick inflammability a desirable quality, so that coke containing a considerable amount of volatile matter is often sold successfully. Even the partially coked coal, known as "Coalite," which is produced by a low-temperature distillation, is preferred to the hard clean coke which is becoming familiar to the American consumer.

Preparation of Coal.

The practice of locating American ovens at the point of consumption of the coke has made it easy to bring together several coals of different qualities, and this has in many cases permitted the production of a better coke by admixture than could be made from either of the coals used alone. For example, a coal of excellent coking qualities but high in ash can be mixed with a low-ash coal of poorer cokability, or an excess or deficiency in the coking quality of the main coal supply can be corrected by mixture with another coal.

Except in cases where the source of coal supply is fixed, it seems desirable to arrange the plant for the preparation and mixing of as many as three kinds of coal. Means permitting the accurate proportioning of the different coals are, of course, essential in such a plant. The mixture of coals generally calls for their being ground quite finely, in order to bring the particles of the different qualities of coal closer together. The general practice is to grind so that from 70 to 80 per cent or more will pass through an ⅛-inch screen. This fine grinding is also often advantageous where there are many pieces of slate of considerable size in the coal, since each large piece of slate in the coke is usually a center of cracks that tend to shatter the structure.

Various degrees of fineness in grinding are often adopted to improve the structure of the coke, but in some cases, especially where only one coal is used, a better structure is produced from considerably coarser coal. Fine grinding reduces the weight of the coal mass per cubic foot, and consequently the capacity of the oven. With ordinary coals the weight per cubic foot of charge is generally taken at from 40 to 43 cubic feet (1.13 to 1.21 cu. m.) per ton, depending somewhat on the coals, and largely on the degree of fineness.

Use of Coals Formerly Considered Unsuitable.

The by-product oven, with its control of heats, coking time, mixture of coals and fineness in grinding, has permitted the use of many coals for making metallurgical coke which would not have been suitable with the beehive oven. As the best coals are being progressively exhausted, this point becomes more important. Owing to the extraordinary conditions caused by the war, some coals hitherto considered entirely unsuitable for making metallurgical coke have been successfully used; for example, the unwashed coals of Southern Illinois.

To use these hitherto unsuitable coals successfully it is necessary to make a careful study of the coking qualities of each one in order that any deficiencies it possesses may be supplied by the proper selection of the coals forming the mixture. Very satisfactory furnace results have been gotten when using important percentages of coals heretofore considered unsuitable, and these results are encouraging on account of the progressive disappearance of the best of the coking coals now available.

Recovery of By-Products.

The distillation or coking of coal in closed retorts, now generally known as by-product ovens, was first introduced for the purpose of saving the several valuable products contained in the volatile matter of the coal, which were all destroyed in the beehive process. The advantages in the production of coke outlined above were not then realized. In fact, it was often thought that a sacrifice of coke quality must be accepted in order that the by-products might be recovered. Fortunately it has developed that the best oven conditions for the production of coke are, in general, the best for the production of by-products also.

The composition of the volatile matter in bituminous coal is very complex and the changes through which these compounds pass during the process of distillation are also complicated. It is not appropriate here to attempt to trace out these changes or to discuss the method of formation of the ammonia, benzol or other by-products. It is well known that only about one-fifth of the nitrogen in the coal combines with hydrogen to form ammonia, and that the remainder is found in the coke and gas.

Attempts have been made to obtain higher yields of ammonia by blowing steam into the coke, somewhat after the manner followed with the Mond producer.

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* Fourth installment of paper read before A. I. M. E. meeting, New York, February, 1918.

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NEWS OF THE PLANTS

LARGE GAS PRODUCER INSTALLATION.

The Mesta Machine Company, at Pittsburgh, Pa., has recently entered into contract with the Smith Gas Engineering Company, of Dayton, O., for gas producers furnishing cold, cleaned gas to replace both fuel oil and natural gas. This producer installation will be the largest cold, cleaned gas plant in the world and will be capable of supplying 40,000,000 cubic feet of producer gas of 140 B. t. u. per cubic foot every 24 hours. The equipment will be installed in eight units, each unit being capable of gasifying approximately 3,500 pounds of bituminous coal per hour.

The first four units will be installed in time to take care of the shortage of natural gas and fuel oil during the winter, the balance to be completed as soon as possible. The gas will be used on all heating work throughout the Mesta plant, including annealing, heat treating and the forging of large billets.

RAIL PRODUCTION.

The American Iron and Steel Institute has recently issued statistical bulletin No. 2, 1918, giving information concerning rail production in the United States in 1917. The following table shows the increase by processes, 1916-17:

Kinds	1916	Per cent	1917	Per cent	Increase	Per cent
Open hearth..	2,269.600	79.51	2,292.197	77.86	22 597	9.95
Bessemer	440.092	15.42	533,325	18.11	93 233	21.18
All other	144,826	5.07	118,639	4.03	*26,187	*18.08
Total......	2,854,518	100.00	2,944,161	100.00	89,643	3.14

* Decrease.

Girder and high T-rails for electric and street railways are included in the figures given above. For recent years the tonnage was as follows: 1912, 174.004; 1913, 195,659; 1914, 136,889; 1915, 133,965; 1916, 127,410; 1917, 91,674 gross tons.

The total production of rails as given above includes, in addition to new rails rolled during the year, rails rerolled from defective rails and from old rails. The total of renewed or rerolled rails so included is given in gross tons below.

The total gross tons of rails rolled in 1917 was 2,944,161 which was 89,543 tons more than in 1916.

The production of rails by weights and processes in 1917 is given in the table below.

	Under 50 lbs.		50 to 84 lbs.		85 to 99 lbs.		100 lbs. & over	
Kinds	Gross tons	Per cent	Gross tons	Per cent	Gross tons	Per cent	Gross tons	Per cent
O. H..	170.182	55 21	473.223	53.61	890.387	89.96	758.405	99.33
Bess..	31.460	10 20	408.580	46.29	88.164	8 91	5,121	.67
Other	106,616	34.59	870	.10	11,153	1.13	....	......
Total	308,258	100.00	882.673	100.00	989,704	100.00	763,526	100.00

Included above is the annual production of alloy-treated rails, shown separately in the tables. The tonnage of rails so treated was first determined in 1909.

COKE PLANT STARTS OPERATION.

The Carnegie Steel Company's Clairton by-product coke plant, consisting of 10 bateries of 64 ovens each, commenced operation June 26. The Koppers ovens will supply coke for the Clairton, Edgar Thomson, Homestead and Duquesne works of the Carnegie Steel Company. The array of ovens will consume 4,200,000 net tons of coal annually, the output of which will be as follows:

Furnace coke, 3,000,000 tons.
Coke breeze, 250,000 tons.
Sulphate of ammonia, 43,000 tons.
Tar, 36,000,000 gallons.
Benzol, toluol and light oil, 10,000,000 gallons.

In addition to these an output of gas, estimated at 75,000,000 cubic feet per day is expected. This will be piped and used by the steel company.

The plan of the Carnegie officials is to get the various batteries in operation as quickly as possible. It was stated that the ovens would produce coke in 16-hour intervals after they have been properly managed. The largest plant in the world before the construction of the present works was that of the United States Steel Corporation at Gary, Ind.

At a special stockholders meeting of Freyn & Co., it was decided to change the firm name to Freyn, Brassert & Co.

PLANT NOT DESTROYED.

Fire damaged the offices of the Medart Patent Pulley Company, St. Louis, Mo., June 22, but no damage was done to the factory which is turning out regular schedule productions. An erroneous report gained circulation that the plant of the company was destroyed; there is, however, no truth in this rumor.

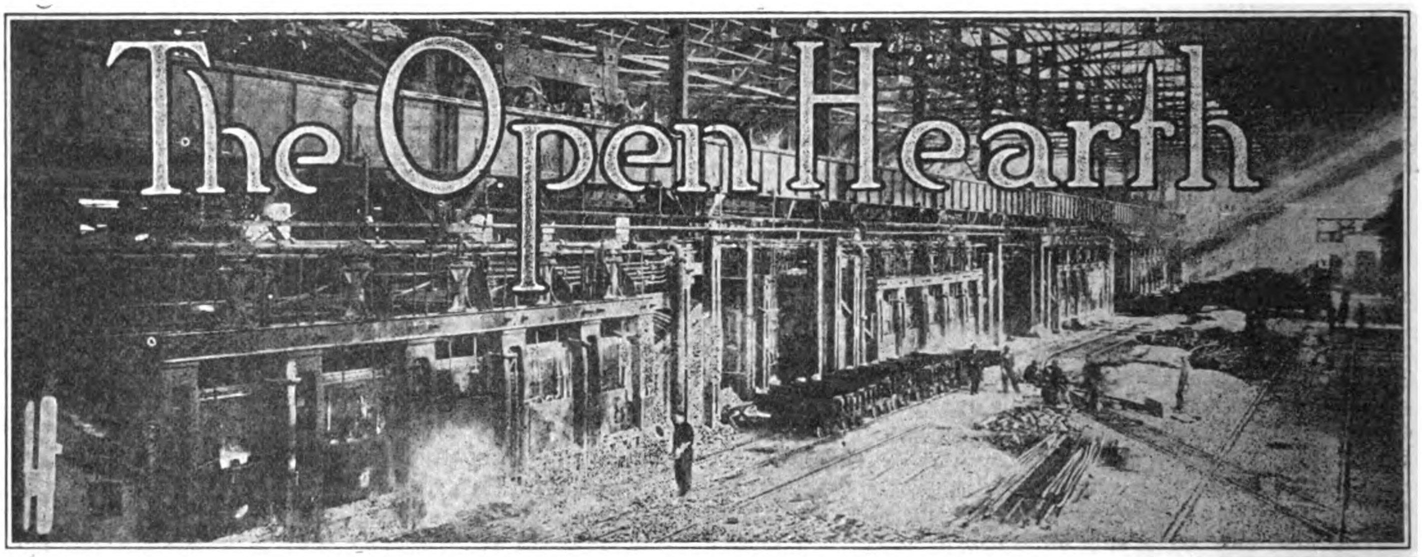
ORDNANCE DEPARTMENT BOARD ON CONSTRUCTION OF UNITED STATES STEEL CORPORATION PLANT.

Gen. C. C. Williams, acting chief of ordnance, has appointed the following officers on a board to represent the Ordnance Department in the preparation and approval of plans for the construction of the Neville Island plant for heavy cannon and projectiles to be constructed by the United States Steel Corporation, under the terms of the existing contract between the corporation and the Ordnance Department. The board will coöperate with the corporation in the planning, construction and operation of the plant:

Col. Charles C. Jamison, Ordnance, N. A., president; Col. Charles M. Wesson, Ordnance, N. A.; Lieut-Col. H. B. Hunt, Ordnance, N. A.; Lieut.-Col. W. P. Barba, Ordnance, N. A.; Lieut.-Col. F. E. Walters, Ordnance, N. A.; Lieut.-Col. R. P. Lamont, Ordnance, N. A.; Maj. Charles A. Walker, Jr., Ordnance, N. A.

The personnel of the board has been selected because of the intimate knowledge of each member of the scientific and practical details of the art of making steel and gun forgings and the raw material to the finished product.

Col. Jamieson, president of the board, was in charge of manufacturing at Watervliet Arsenal for 4½ years. Col. Wesson was for years connected with Watervliet and is now in command at Watertown Arsenal, and is a steel expert of wide experience. Col. Hunt has had a long and interesting experience in large manufacturing enterprises, and Lieut-Col. Barba was for 37 years connected with the Midvale Steel Company, rising from messenger boy to vice president and general manager. Col. Walters is a construction engineer of wide experience and will be in charge, to a large extent, of planning and building construction. Col. Lamont, president of the American Steel Foundries, is also one of the best known and most capable steel and ordnance experts in the country.



The following are elected to associate membership of the American Iron and Steel Institute: Joseph D. Billard, New York City; Allan S. Bixby, Indianapolis, Ind.; James V. Davison, Cleveland, O.; James W. Donner, Dayton, O.; Grafton D. Dorsey, New York City; William M. Duncan, Alton, Ill.; Otto J. Fehling, Chicago, Ill.; William Garrow Fisher, New York City; J. D. Forrest, Indianapolis, Ind.; C. E. Gault, Topeka, Kans.; George A. Hart, Melrose Park, Ill.; Charles W. Hotchkiss, Cleveland, O.; Carl T. Keller, Boston, Mass.; Saul Lavine, Pittsburgh, Pa.; Oliver W. Loomis, Cleveland, O.; Charles W. McClure, Youngstown, O.; Porter Pollock, Youngstown, O.; Harry W. Pratt, New York City; E. W. Sheldon, Erie, Pa.; Frank M. Sheldon, Boston, Mass.; James A. Slater, Chicago, Ill.; Loren B. Wilson, Toledo, O.; C. W. Sherman, Hamilton, Ontario, Can.; Lee D. Brueckel, New York City; William Wuthenow, Chicago, Ill.; Olin R. Kuhn, Pittsburgh, Pa.; Fred A. Bigelow, Reading, Pa.; Roy C. McKenna, Latrobe, Pa.; James E. Fitzgerald, Youngstown, O.; Roy Carnahan, Canton, O.; Frank A. Robbins, Steelton, Pa.; Rollin W. Lusk, Pittsburgh, Pa.; G. F. Ahlbrandt, Middletown, O.; Charles Prescott Rees, Sterlington, Rockland County, New York; Wheaton Bradish Kunhardt, Reading, Pa.; Allen Hoffer, Cleveland, O.; George W. Whitehead, Buffalo, N. Y.; Harry G. Uphouse, Philadelphia, Pa.; Charles A. Menk, Munhall, Pa.; Lee Deutsch, New York City; William L. Hoffman, Philadelphia, Pa.; William C. Dicky, New York City; William F. Vosmer, New York City; A. A. Templeton, Detroit, Mich.; Robert McGregor, Kearny, N. J.; Charles S. Belsterling, New York City.

The following are elected to active membership of the American Iron and Steel Institute: Edwin F. Barnes, Worcester, Mass.; Paul J. Kruesi, Chattanooga, Tenn.; Clifton L. Lingo, Indiana Harbor, Ind.; Arthur H. Jameson, Bayonne, N. J.; James Duane, Jr., Parryville, Pa.; Waldemar Dyrssen, New York City; Ferdinand E. Canda, New York City; Charles A. Gould, New York City; Orville P. Blake, Washington, D. C.; S. Kuker, New York City; Otway B. Newton, Roanoke, Va.; Charles H. Forster, Pittsburgh, Pa.; Olof Tangring, New Haven, Conn.; Peter Stewart, Worcester, Mass; Thomas McCaffrey, Brier Hill, Pa.; J. Lester Perry, Worcester, Mass.; Robert S. Lackey, Buena Vista, Va.

* * *

Chester F. Hockley, formerly master mechanic at the Saucon plant of the Bethlehem Steel Company, severed his connection with the company on May 4, to become vice president and general manager of the Hammered Piston Ring Company, of Newark, N. J. Mr. Hockley has been an employe of the company since May 1, 1908, when he became superintendent of construction of the power department. This position he held until March 1, 1916, when he was appointed to the position he held at Saucon.

* * *

R. Tencher, who was formerly connected with the Illinois Steel Company's South works for 13 years, and for the past year and a half has been general superintendent of steel plant of the Keystone Steel & Wire Company, Peoria, Ill., has resigned from that company because of ill health, and will take an extended rest with his family at Wilmette, Ill.

* * *

Thomas Finigan has been elected vice president of the American Brake Shoe & Foundry Company.

* * *

L. E. Thomas has been appointed chief engineer of the Neville Island ordnance plant. Mr. Thomas was formerly chief draftsman of the National Tube Company, at Lorain, O.

* * *

H. G. Spilsbury, metallurgical engineer for the Metal & Thermit Corporation, who was formerly in Pittsburgh, will be located at the home office of the corporation at New York.

* * *

Newlin T. Booth, formerly assistant superintendent of the steel foundry department of the Bethlehem Steel Corporation, South Bethlehem, Pa., has been made superintendent. Bent L. Weaver, who formerly held this position, is now head of the Vulcan Iron Works, Wilkes-Barre, Pa.

* * *

Robert J. Anderson, government resident chemist at Youngstown, is now with the government laboratories of the Signal Corps, at Pittsburgh, Pa. He was resident chemist at Youngstown and located at the government laboratories of the Youngstown Sheet & Tube Company.

* * *

Ralph A. Walters will be superintendent of steel construction and installation of the Neville Island ordnance plant. He is now assistant superintendent of the American Bridge Company, Pittsburgh, Pa.

* * *

E. C. Smith, formerly with the Schloss-Sheffield Steel & Iron Company, Birmingham, Ala., is now connected with the sales staff of the Matthew Addy Company, Cincinnati, O.

* * *

George C. Brainerd, of the Hydraulic Pressed Steel Company, Cleveland, O., will work in connection with Samuel

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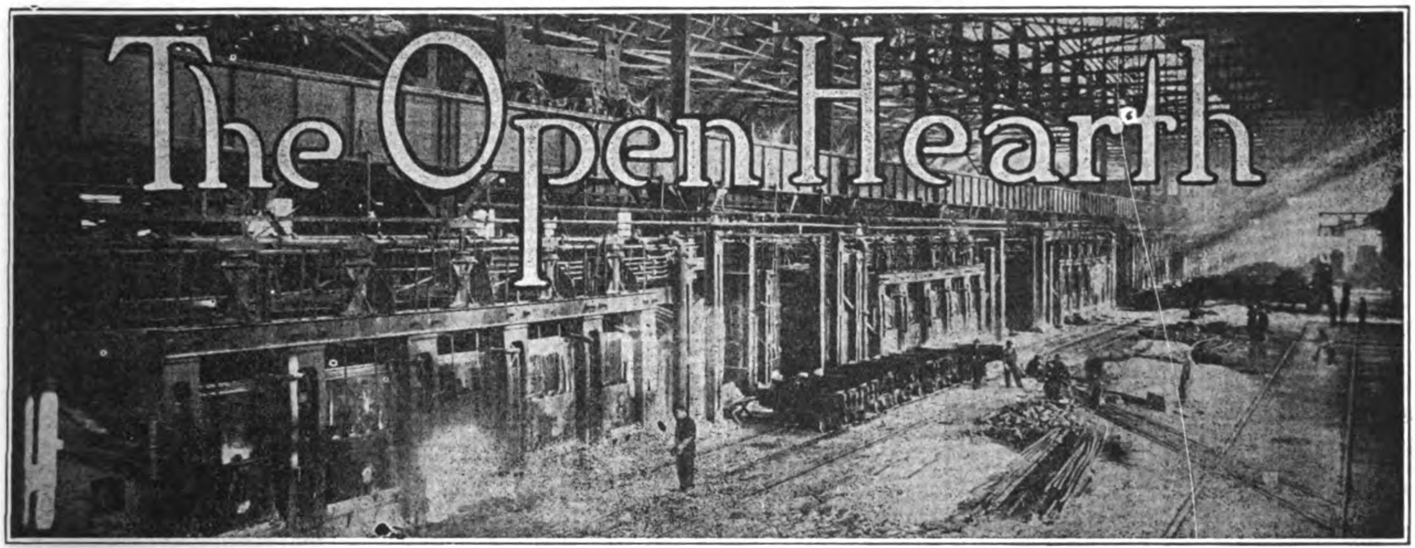

Scovil, who is now district chief of ordnance at Cleveland. Mr. Brainerd will specialize in the production of shell forgings.

V V

J. R. McWane, president of the American Cast Iron Pipe Company, Birmingham, Ala., has assumed his duties as chief of operating standardization of the Emergency Fleet Corporation.

V V

James L. Wick is now special agent of the Youngstown Sheet & Tube Company, Youngstown, O. This position was formerly held by Roy Welch, who is now assistant to president J. A. Campbell.

V V

L. N. Ralph, who was in the rail and billet division of the Carnegie Steel Company, has been appointed assistant secretary and assistant treasurer of the Neville Island ordnance plant.

V V

Arthur A. Clement, president of the American Wire Fence Company, Chicago, Ill., and son of the late Austin Clement, has been elected vice president of the Page Steel & Wire Company, Pittsburgh, Pa.

V V

Lloyd Booth, treasurer of the Trumbull Steel Company, Youngstown, O., is now training in the aviation corps. He has been granted an indefinite leave of absence.

V V

Charles B. Seem, formerly with Perin & Marshall, consulting engineers, New York City, has become actively connected with the Electric Furnace Company, Alliance, O., in the capacity of sales engineer.

V V

I. Lamont Hughes, formerly general superintendent of the Canadian Steel Corporation, Ltd., and prior to that bar mill superintendent of the Youngstown Sheet & Tube Company, has been appointed general superintendent of the ordnance plant to be erected at Neville Island.

V V

O. G. Jenner, mechanical engineer of the Chicago Heights plant of the Inland Steel Company, at Chicago, Ill., has resigned.

V V

W. J. Long has been elected president of the National Steel Products Company, Bessemer, Ala.

V V

Fred Hubbard will be chief civil engineer for the Neville Island plant. He is at present construction superintendent and efficiency engineer of the Carnegie Steel Company, at Youngstown, O.

V V

Col. Henry B. Bope, has been elected vice president of G. G. Gynson & Co., New York. He was formerly vice president and general manager of sales of the Carnegie Steel Company.

V V

George Hutchinson, formerly superintendent of yards of the Tennessee Coal, Iron & Railroad Company, has been transferred to Mobile, where he will be superintendent of construction of the Chickasaw Shipbuilding plant of the same company. C. E. Farnum succeeds Mr. Hutchinson at Ensley.

V V

M. C. Turpin, formerly connected with the publicity department of the Westinghouse Electric & Manufacturing Company, is now in the Federal service as assistant to the manager of the technical publicity bureau of the Ordnance Department.

V V

Lieut.-Col. Thomas C. Clarke, formerly manager of the Lehigh coke plant, at Bethlehem, Pa., has received the Croix de Guerre for distinguished bravery in action in penetrating the enemies' trenches for a half mile. Lieut-Col. Clarke is an officer of the Thirty-fifth Division, One Hundred and Tenth Engineers.

V V

John N. Coffin, formerly assistant secretary-treasurer of the Tennessee Coal, Iron & Railroad Company, is now located in Washington as assistant manager of the requirements section of the Emergency Fleet Corporation.

V V

Allen A. Templeton, president of the Detroit Seamless Tubes Company, has been appointed superintendent of industrial zone No. 8 by the War Industries Board.

V V

A. B. Cole has been appointed assistant to the manager of the department of publicity, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. He succeeds M. C. Turpin.

V V

Philip M. Cuba has assumed his duties as New York district sales manager of the Donner Steel Company, Buffalo.

INDUSTRIAL SAFETY

THE SAFETY ENGINEER.

By L. A. De Blois.*

Seven years ago I visited the Gary plant of the Illinois Steel Company, in the interests of reducing the number and severity of the industrial accidents occurring in the plants of the Dupont company. The United States Steel Corporation, of which the Gary plant was a subsidiary, had even then established an enviable reputation for its work in accident prevention. The report of this visit, which is now a very painful one for me to read, briefly disposed of the subject by stating that accomplishments at Gary could be roughly divided into two classes: mechanical safeguarding, which was excellent, and safety advertising, which the writer believed was undertaken to convince the general public that the steel industry, with a reputation for innumerable serious accidents, was not so black as it had been painted.

As I reflect on these earlier impressions and realize that over a year passed before I fully appreciated the injustice I had done the work at Gary, I wonder how many engineers and executives think to-day as I thought then—that safety engineering is merely a matter of safeguarding and advertisement. Yet, if I were asked for an opinion, I would say without hesitation that the foreman and skilled laborer in our modern industries have a somewhat clearer conception of and entertain a more cordial feeling toward the safety movement than many engineers and executives. It is partly for this reason that I am anxious to-day to persuade those who have heretofore considered the "safety first" movement as a fad or a frill that safety engineering is true engineering, that freedom from accident hazards should be a fundamental requisite in the design of structures and machines and a rigid necessity in plant operation, and that the greatest obstacle in the path of such attainment exists in a certain apathy to the safety movement among engineers in general and in a very definite and lamentable scarcity of trained safety engineers technically fitted to carry forwark the work.

Field of Safety Engineer Defined.

Let us attempt to define the field of the safety engineer's activities. His goal is, of course, the reduction or elimination of accidents. Analysis of industrial accidents shows that from 15 to 25 per cent are unavoidable. In the Dupont company, which I am happy to represent, these are the cases which we attribute to "Risk of Employment," "Unknown Physical Deficiency," and "Act of God," and they may be passed by with the brief statement that the number is gradually decreasing as the general knowledge of accident prevention broadens. Of the remainder, or avoidable accidents, between 10 and 20 per cent are caused by unsafe mechanical or structural conditions and are therefore possible of correction. This leaves 80 to 90 per cent attributable to human defects, that is, to the short-comings of the individual—ignorance, carelessness, irresponsibility, indifference, disobedience, recklessness, horseplay and inexperience of the injured or fellow employe—and to defects of system such as lack of proper supervision, discipline, etc., in the organization.

Obviously, the safety engineer may not confine his attentions solely to the elimination of those accidents for which his employer or company could be judged responsible under the common law of master and servant; he seeks to eliminate all accidents regardless of responsibility. Each accident is an interruption to output, a needless expense, a cause of suffering, and a drain on the resources of the community and of the country at large. In 1916 there were approximately 22,000 persons killed in industrial accidents in this country alone and 500,000 injured to the extent of losing over four weeks from work. Such wastage of man-power and production is in the aggregate enormous and constitutes a monetary loss of serious proportions. Unfortunately, its dollars-and-cents equivalent cannot be readily estimated. Workmen's compensation acts, which have largely rendered unnecessary recourse to suits at common law, practically ignore the question of relative responsibility and place approximately one-half the burden of accident compensation for all accidents on the shoulders of the employer. In establishing a rate of compensation, however, these acts make no attempt to evaluate life and limb but, based somewhat on the average net judgments for damages in suits at common law, aim rather to fix on the industries a fair proportion of the financial burden. It is not reasonable, therefore, to assume that the cost of accidents to the people of any state is represented by the total annual payments for compensation. Losses incident to injury or death are in one sense no more compensable than losses by fire are "covered" by insurance. In both cases there has been withdrawn from the nation's reservoir man-power, or property representing man-power, which can never be replaced.

A remarkable thing about the preceding analysis of industrial accidents is that it seems to apply equally well to any industry. The Dupont company, for instane, which is engaged in the manufacture of the most dangerous materials used in both industry and war—explosives, ammunition and strong acids—discovers about the same assignment of responsibility for accidents as does the cement industry. Mining, railroads, and other industries have the same experience. Moreover, the non-fatal and fatal accident rates in the Dupont company's plants do not themselves differ greatly from the rates of other and so-called "non-hazardous" industries Both premises lead us directly to the logical, though somewhat surprising, conclusion that neither the nature of the industry nor the character of the materials produced or handled has as much effect on the cause, frequency and severity of accidents as the safe design and equipment of plants, the provision of a proper organization and constant supervision and the education of the working force into habits of caution and careful practices.

Have we not in this way defined the field of the safety engineer's activities and accredited him to all the provinces of design, equipment, organization, supervision and education? His influence must surely spread into each of them if consistent accident prevention is to be attained. But in reality they cover practically the whole vast territory of industrial projection, construction and operation.

There may be some who would at first object radically to the intrusion of the safety engineer's ideas in all these matters, especially since, as the exponent of "safety first," he is sometimes accused of interference with production. Let us examine this from the practical side.

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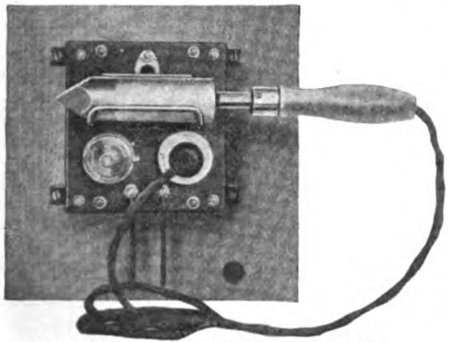
* First part of paper presented at the spring meeting. Worcester, Mass., June, 1918, of The American Society of Mechanical Engineers.

WITH THE EQUIPMENT MANUFACTURERS

RACK FOR ELECTRIC SOLDERING IRONS.

Electric soldering irons which are left to lay on a bench or other convenient place when temporarily not in use, gather dirt and become a hazard. Often the tip will be overheated, necessitating refiling; the heating unit may burn out; or the hot iron set fire to the bench or other material. If the current is turned "off" the iron cools down to such a degree that considerable delay is caused when the iron is again wanted.



Automatic soldering iron rack.

To overcome these objectionable features the Cutler-Hammer Manufacturing Company, of Milwaukee and New York, has recently developed an automatic soldering iron rack and control panel which decreases the amount of current taken by the iron when it is placed on the rack. This keeps the iron from overheating, prevents burnouts, and saves current and further encourages orderliness by providing a convenient connection point and support for the iron. The rack consists of a small slate panel arranged for wall mounting and carrying a support for the iron which acts on the principle of the telephone receiver hook. When the iron rests on the support or hook it bears the support down and resistance which is mounted on the back of the panel is inserted in circuit with the iron. The current is reduced and the temperature held at a safe value, but ready for service and full current just as soon as the iron is lifted from the hook. Taking the weight from the hook disconnects the resistance from the soldering iron circuit and allows full current to flow. Below the hook, on the same panel, there is a push button snap switch and a "Standard" receptacle to which the plug of the soldering iron cord is connected. This little panel, therefore, is a complete switchboard which may be mounted on the wall or machine within reach of the workman. When not in use and at night, the switch is snapped "off" which completely opens the circuit to the iron.

Workman placing soldering iron on automatic rack.

WINANS' NEW IDEA VISE.

The Barnett Foundry & Machine Company, Irvington, N. J., has just brought out a machinist's bench vise under the name of "Winans' New Idea Vise" that embodies many novel features. The old-fashioned screw and lever has been replaced by a pawl and rack. This is actuated by a handle on an eccentric shaft, which will exert a pressure many times that possible with a screw.

The adjustments from zero to maximum are made instantly with one sliding movement. The pawl eccentric and sliding jaw form a toggle joint, bringing the greatest pressure to bear on the top part of the jaws, causing the work to be clamped tightest at the working part. The moving member of the vise slides away from the operator and there is no handle between operator and the vise. The gripping plates are hardened and ground, and the rack and pawl are also made of hardened steel.

A feature of especial importance is that the whole vise may be removed from its swivel base and taken to surface plate, drill press or milling machine for continuous operations, since the base of the vise is accurately machined to right angles with the jaws. These vises are made in standard sizes of jaws, from 3 to 8½ inches, and openings of 3½ to 12 inches. The whole design is such that it will stand up under the most trying conditions.

BENCH DRILL.

The Wisconsin Electric Company, Racine, Wis., has brought out a new electrically driven, sensitive bench drill. The motor is directly connected to the spindle. The motor is of the variable speed type and affords six speeds ranging from 500 to 10,000 revolutions per minute. The controller is mounted on the floor and is operated by a foot pedal.

The platen is adjustable and affords a stroke of ½-inch through the medium of the hand lever at the right of the machine. The drill is said to be adapted for drilling steel, cast iron, aluminum, brass, fiber, hard rubber, etc. It has a capacity up to 1/16-inch in steel and ⅛-inch in soft alloys. Holes can be drilled in the center of a 5-inch circle. The motor and chuck are balanced dynamically to insure smooth running.

NEW LOCK NUT.

The Evertite Nut Corporation, Marquette Building, Detroit, Mich., has placed on the market a lock nut called the Sta-Lok, which depends upon two steel balls enclosed in the nut for its locking action. A recess in which two hardened steel balls separated by a short coil spring are located is provided parallel with the upper and lower faces of the nut and extends half way in. When the nut is placed on the bolt the inner of these two balls rides in the groove between the bolt thread and is kept in contact with them by the action of the spring.

Trade Publications

Centrifugal Boiler Feed Pumps—In a pamphlet entitled "Centrifugal Boiler Feed Pumps," the De Laval Steam Turbine Company, Trenton, N. J., describes the De Laval combined steam turbine and centrifugal boiler feed pump. Centrifugal pumps have been used for feeding high pressure steam boilers for a number of years, but the machine here described differs from those previously used in that the steam turbine rotor and the pump impellers are mounted upon one shaft with only two bearings and are enclosed within one housing. The combined turbine pump casing is split horizontally, and by lifting the cover all internal and working parts are exposed. The steam and water connections are in the lower part of the casing and are thus not disturbed when the pump is opened. The turbine is of the velocity-stage type and the pump contains either two or three impellers, according to the boiler pressure.

One of the most remarkable features is the extremely small size and weight of this type of pump. A pump for 3,000 boiler horsepower occupies a floor space of only 2 by 3 feet as against about eight times that space for an ordinary duplex pump. Turbine-driven centrifugal pumps in one housing are made in capacities from 2,000 to 10,000 boiler horsepower. For larger units up to 60,000 hp the pump and turbine are built separately but mounted upon a common base plate. The pamphlet also describes electric motor-driven units.

Steel Pipe—The National Tube Company has issued a bulletin entitled "28 Years of Steel 'National' Pipe Progress" in which the progress and increased use of steel pipe is diagrammatically illustrated. The National Tube Company also explains the definition and distinction between the terms "wrought pipe," "wrought iron pipe" and "steel pipe," as follows:

(1) Wrought Pipe—This is the generic term for steel or iron pipe. The average dealer in pipe refers to himself as a "dealer in wrought pipe"—which means that he sells both steel and iron pipe.

(2) Wrought Iron Pipe—This means just what it says, namely, wrought iron pipe—the product of a puddling furnace—and embraces about 10 per cent of the wrought pipe made in this country.

(3) Steel Pipe—This also means exactly what it says—and represents about 90 per cent of the present output of wrought pipe in this country.

Lillie Evaporator for Waste Waters—The first booklet relating to the Lillie evaporator, published by the Wheeler Condenser & Engineering Company, Carteret, N. J., is just off the press. The Lillie evaporator is now manufactured exclusively by this company under agreement with the Sugar Apparatus Manufacturing Company; S. Morris Lillie, president, owners of the Lillie patents. This new booklet calls attention to the factors which make the Lillie multiple effect vapor reversing evaporator especially suited to the concentration of waste waters or liquors in numerous industries.

Compressed Air—The Ingersoll-Rand Company, New York, has recently issued a number of bulletins as follows: "Ingersoll-Rand Equipment for Sugar Factory and Refinery Service" descriptive of I. R. vacuum pumps, both steam and power driven; counter cement barometric condensers, centrifugal and reciprocating pumps and pneumatic tools. Another pamphlet describes and illustrates the I. R., the Leyner shank and bit punch for punching out the holes in bits of and shanks of hollow drill steel. Other bulletins describe the portable mine car air compressors, ticket cancelling box, pneumatic caulking tools and the "Little David" evaporator tube cleaner.

Wheeler-Balcke Cooling Towers is the name of Bulletin 109-B just published by the Wheeler Condenser & Engineering Company, Carteret, N. J. This 28-page bulletin shows Wheeler-Balcke cooling towers of numerous designs in capacities varying from a few thousand gallons per hour to nearly a million gallons per hour. It is shown better, in some cases, to combine natural and forced draft. Two pages are devoted to Wheeler-Barnard forced draft cooling towers which are at times found preferable to the Wheeler-Balcke. Wherever sufficient ground area is available, however, the Wheeler-Balcke is usually considered by consulting engineers as the standard natural draft tower.

Department of the Interior New Publications — Technical Papers — Technical Paper 148, "The Determination of Moisture in Coke," by A. C. Fieldner and W. A. Selvig. 1917. 14 pp. Technical Paper 182, "Flotation of Chalcopyrite in Chalcopyrite-Pyrrhotite Ores of Southern Oregon," by Will H. Coghill. 1918. 13 pp., 1 fig. Technical Paper 183, "New Views of the Combustion of the Volatile Matter in Coal," by S. H. Katz. 1918. 15 pp., 1 fig. Technical Paper 201, "Accidents at Metallurgical Works in the United States During the Calendar Year 1916," by Albert H. Fay. 1918. 18 pp.

Trade Notes

The Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., has purchased the property, business and good-will of the Krantz Manufacturing Company, Inc., Brooklyn, N. Y., manufacturers of safety and semi-safety electrical and other devices, such as autolock switches, distribution panels, switchboards, floor boxes, bushings, etc. The supply department of the Westinghouse Electric & Manufacturing Company will act as exclusive sales agent for the products of the Krantz Manufacturing Company, whose business will be continued under its present name. H. G. Hoke, of the Westinghouse Electric & Manufacturing Company, will represent the supply department at the Krantz factory.

The Quigley Furnace Specialty Company has opened an office at 427 Oliver Building, Pittsburgh, Pa. L. V. Marso, formerly maintenance engineer with the A. M. Byers Company, is in charge, and John L. Cummings, Jr., is in charge of the specialty department.

Booth-Hall Company, 565 West Washington baulevard, Chicago, Ill., metalington boulevard, Chicago, Ill., metaltric furnaces for the melting, smelting and refining of metals, have just concluded arrangements with the Bradford-Ackermann Corporation, 30 East Forty-second street, New York City, to take entire charge of sales in the Eastern section of the United States. Both Messrs. C. C. Bradford and A. H. Ackermann have had extensive experience in the sale of electrical apparatus. They are both graduate electrical engineers. Mr. Ackermann was formerly vice president and general manager of the United States Light & Heat Corporation, Niagara Falls, N. Y., and Mr. Bradford was general sales manager of the same company. Their acquaintance is a broad one throughout the trade in the East and their large experience in the handling of electrical problems will be of great advantage to all those considering the installation of electric furnace equipment.

The San Francisco office of the Blaw-Knox Company has been removed from the Rialto Building to its new office and warehouse at 528-30 Second street.

R. L. Lunt, the well-known electrical engineer of Minneapolis, Minn., has just become connected with the sales department of the Packard Electric Company, having charge of the Minneapolis branch. For years Mr. Lunt was connected as sales engineer of the Western Electric Company's Philadelphia office. From here he went with the Electric Storage Battery Company, of Philadelphia, Pa. He has also been in the contracting (electrical) business for himself, all of which has fitted him for his present position. The Packard Electric Company, general office and works, Warren, O., is one of the oldest and best known producers of transformers of all sizes, ignition, starting and lighting cables for automobiles, trucks, aeroplanes, tanks and gas engines of all types. Mr. Lunt is located at 716-18 McKnight Building, Minneapolis, Minn.

Society Meetings

The annual convention of the Association of Iron and Steel Electrical Engineers will be held at the Southern Hotel, Baltimore, Md., September 9-14.

National Safety Council annual congress for 1918 will be held the first week in October, at the Hotel Statler, St. Louis, Mo.

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The Blast Furnace and Steel Plant

Pittsburgh, July, 1918

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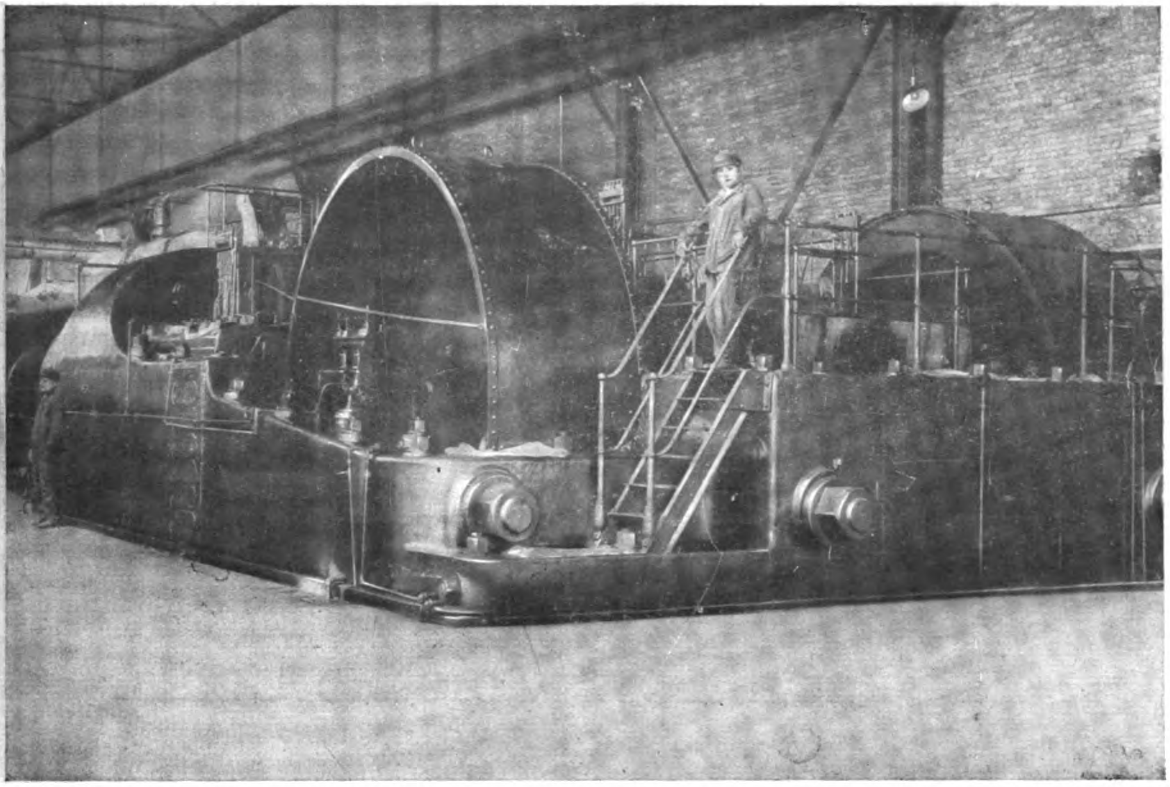

The above illustration shows a large Blooming Mill engine, operating in the Pittsburgh district, babbitted throughout with "NOHEET." Tin base metals formerly were used without entirely satisfactory results. "NOHEET has given longer and better service at greatly reduced cost, INCIDENTALLY, CONSERVING TIN TO A MAXIMUM DEGREE.

"NOHEET" is particularly adaptable for all classes of work from the high speed and heavy duty engines to the least worked bearing in the plant. It gives longer service than tin base metals and many times the service of other mixtures.

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